DOCUMENT RESUME

ED 031 756 24 CG 004 311

By-Erdmann, James B.; Buchi, Dorothea M.
A Comparative Study of Problem Solving Processes Relative to the Models Developed by Jean Piaget and Loyola University. Final Report.
Loyola Univ., Chicago, Ill. Psychometric Lab.
Spons Agency-Office of Education (DHEW), Washington, D.C. Bureau of Research.
Bureau No-BR-7-E-192
Pub Date Sep 68
Grant-OEG-0-8-000192-1807-010
Note-136p.
EDRS Price MF-$0.75 HC-$6.90
Descriptors-*Cognitive Processes, *Intelligence Tests, *Measurement Instruments, *Models, *Problem Solving

The basic problem under investigation was the determination of empirical relationships between two models, developed by Piaget and Loyola University and employed in the assessment of cognitive processes in a problem solving context. Among objectives explored were: (1) investigation of the sensitivity of the intelligence test in distinguishing levels of education, and (2) investigation of the sensitivity of each Piaget experiment in distinguishing levels of education. Findings included: (1) all three Piaget experiments, both in terms of a major stage and substage analysis, distinguished levels of education; and (2) Loyola verbal problems were found effective in distinguishing the major stages of the Combinations and Balance experiments of Piaget, but not of the Probability experiment. The Loyola geometric problem was ineffective in all three instances. The evidence seems to suggest that the similarities of the two models are of a superficial nature, such as content or symbols involved in the specific instruments of the positive instances. (Author/KJ)

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September, 1968

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HEALTH, EDUCATION, AND WELFARE

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Acknowledgements

The authors wish to express their sincere gratitude to the Swiss Federal Institute of Technology, specifically to Drs. Hans Biäsch and Hardi Fischer of the Institut für Arbeitspsychologie who generously made available the facilities of the latter institute for the conduct of this research. Special thanks are owed Dr. Fischer who made available members of his staff, established necessary contacts, and freely offered the benefits of his professional experience, particularly in matters relating to the work of Jean Piaget. The co-operation and assistance of all the personnel of the Institut für Arbeitspsychologie deserve appropriate recognition.

In addition, the authors wish to recognize the contribution of the school officials of Zürich and Winterthur as well as the headmasters and teachers of the various schools, who provided the subjects for this research.

Another debt of gratitude is owed Mr. Henry Keller and his staff of Bull-General Electric of Zürich, who rendered indispensible assistance, often at great personal sacrifice, in the computerized analysis of the data.

Finally, the authors wish to acknowledge with gratefulness the inspiration and advice of Dr. Horacio J.A. Rimoldi, Director of the Loyola Psychometric Laboratory, who contributed in many ways throughout all phases of this research.

Summary

In the research to be reported the basic problem under investigation was the determination of empirical relationships between two models employed in the assessment of cognative processes in a problem solving context. The models involved are those developed by Jean Piaget and Loyola University. Such a comparison was deemed advantageous because of the possibilities of one model serving a complementary function for the other. By way of clarification, both models involve concepts with apparently similar definition and both have at their basis a heavy emphasis on the logical operations involved. Yet these communalities were a consequence of quite disparate theoretical and empirical formulations. Hence, some basis for theoretical implications from the theory-dominated Piaget model was sought as a complement to the experimentally oriented Loyola technique.

This purpose was pursued by administering a sampling of instruments from both models to a sample of Swiss students. These subjects were further identified in terms of their level of academic achievement and performance on a standardized test of intelligence. Since this is an initial inquiry into the area, the focus of the study was limited to a determination and identification of any empirical relationships.

In view of the information available, the following objectives were explored:

1.) Determination of a preferred method of scoring the Loyola problems based on the various methods' abilities to distinguish performance on these problems for groups defined by levels of education and quartiles on the intelligence test;

2.) Investigation of the sensitivity of the intelligence test in distinguishing levels of education;

3.) Investigation of the sensitivity of each Piaget experiment in distinguishing levels of education;

4.) With the preferred measure, the determination of possible differences in performance on the various Loyola problems for groups defined by their stage performance in each Piaget experiment;

5.) Investigation of possible differences in performance on the intelligence test for groups defined by their stage performance in each Piaget experiment;

6.) Identification of the factorial composition of the combined Loyola and intelligence variables for the total sample;

7.) Identification of the factorial composition of the combined Loyola and intelligence variables for groups defined as performing at particular stages in each Piaget experiment, when feasible; and,

8.) Comparison of the various factor structures if such proves meaningful.

In order to achieve these objectives, usual tests of significance, analysis of variance, covariance techniques, and factor analysis were employed.

Identifying phases by the objectives pursued, the general findings were:

1.) No discrimination was possible between the three methods of scoring in terms of a preferred method for distinguishing quartiles groups established by subtests of the intelligence instrument. All methods were equally effective in distinguishing quartiles and levels of academic achievement. In general, quartiles of verbal and quantitative abilities were distinguishable by all Loyola problems, as were the levels of academic achievement.

2.) With the exception of the Cube Problems subtest, all subtests of the Amthauer Intelligenz Struktur Test distinguished levels of education (academic achievement).

3.) With negligible exceptions, all three Piaget experiments, both in terms of a major stage and substage analysis, distinguished levels of education.

4.) Loyola verbal problems were found effective in distinguishing the major stages of the Combinations and Balance experiments of Piaget, but not of the Probability experiment. The Loyola geometric problem was ineffective in all three instances.

5.) Only two of the Amthauer subtests effectively distinguished major stages for all three experiments, and the former were one verbal and one quantitative subtest. The memory subtest was completely ineffective. The remaining six subtests distinguished in some instances, but not in others, and yielded no systematic relationship.

6.) Objectives 6, 7 and 8 dealt with the factor analysis of the combined Loyola and Amthauer batteries. The initial results indicated the necessity of resolving certain methodological issues. These presume efforts beyond the scope of the present study, but, assuming a satisfactory solution to the methodological problems, the initial results look promising for this line of inquiry.

Thus empirical relationships have been demonstrated, but it does not seem that they are of so general a nature to warrant the conclusion that theoretical issues are at the basis. In fact, the evidence obtained seems to suggest that the similarities are of a superficial nature, such as the content or symbols involved in the specific instruments of the positive instances.

The obvious conclusion of this research is that similarities between the two models should be reduced to two representative instruments or at least to two representative types of instruments. Future research is definitely indicated in identifying the representatives of each model involved, since a general relationship has not been found.

Finally, in the opinion of the present authors, the primary benefit for the field of education of the Piaget model is the possibilities it offers for comparative study with techniques more readily and more feasible applicable to the educational setting.

Somewhat unrelated to the central problem, the Loyola technique was demonstrated effective with a non-American and non-Engligh speaking sample and most of its previous findings were again verified.

I. Introduction

A General

The study of problem solving behavior has been approached by many avenues. Various different models have been expounded and there have even been attempts at classifying these models. It seems safe to say that a very broad classification could be made of those investigations which give special emphasis to or focus particular attention on the process involved in the problem solving situation. Further it seems possible to narrow the scope a little more by distinguishing, among those in the broad classification, the studies which have a quantifiable experimental basis from those for which quantification is more difficult and which have a heavy theoretical orientation. Perhaps, with limitations, the difference could be the often cited one between the American and European traditions of psychology, respectively.

The above considerations were proposed in order to set the general framework within which the present authors see the research which follows. Two approaches were explored both of which definitely place special emphasis on the study of the process in the problem solving situation. One approach (hereafter called the Loyola technique) proposes to obtain a quantifiable measure of the problem solving process based on objective and experimentally defined criteria. The other approach, that of Jean Piaget, the Swiss psychologist from Geneva, is more subjective and intuitive in its characterization of the problem solving process, analyzing the latter in terms of the mathematico-logical operations involved. No value judgments are intended, for it was the present authors' contention, at the onset of the research, that an empirical study of the relationships between the two approaches would yield valuable information which could prove enriching for both.

At this point it seems in order to consider somewhat more of the background of the two approaches, in order to see more clearly where the benefits of such a research may be expected to derive.

The Loyola technique was developed at the Loyola Psychometric Laboratory, Loyola University, Chicago, by its director, H. J. A. Rimoldi, and his associates. The technique was the response to a particular problem, namely, the characterization and evaluation of the medical diagnostic process. For this purpose instruments and means of evaluating them were devised. Interest in this research gradually evolved to include the general area of problem solving with its many correlates and specific applications. Correspondingly, new problems were devised which could be defined experimentally and and logically, and scoring procedures refined. In the course of this development, various theoretical hypotheses have been formulated and tested, and, while prospects are optimistic, progress is necessarily slow, so that it is not possible to say that presently the theory surrounding the Loyola technique is at a highly developed stage.

The approach of Piaget differs in several respects from the preceeding. In its origins one does not find such a specific problem as stimulus for development, certainly not with the practical connotations. Piaget, in his work in cognition, was interested in its developmental aspects. Therefore, from the start, his purpose was more general, and a theoretical exposition of the area was more his goal. He thought he saw in mathematico-logical operations a model for explaining cognitive functions and their development. Philosophical considerations especially of an epistemological nature are very important as well, in the formulation of his theory. The various experiments he contrived were meant to provide additional information for, and to serve as illustrations of various aspects of, his theory. In this framework a quantifiable measure of performance does not take on indispensable importance. In this respect, then, for Piaget quantification has suffered at the expense of theory whereas with the Loyola technique progress in theory is limited by the development of appropriate measures.

While the above may be somewhat of an oversimplification, it does serve as a basis for observing where benefits are likely to accrue to each approach from an experimental comparison of their relationships. Very briefly put, then, while the Loyola approach may be incomplete from the standpoint of theory, the Piaget approach is lacking in terms of an experimentally acceptable and quantifiable means for the assessment of cognitive behavior. In this connection it must be stated that it is not the present author's interest to offer possible solutions to these deficiencies in the Piaget approach, though this problem could not be ignored completely. Therefore, when appropriate, these matters will be discussed more extensively. However, it is the admitted purpose of the present authors to make use of the information from the comparison of the two approaches as a contribution to the theoretical development of the Loyola technique, if this proves possible. Such an eventuality seems particularly plausible considering the importance of logical relationships in the instruments of the Loyola technique, on the one hand, and in Piaget's theoretical discussions of cognitive operations, on the other. The absence of similarities in the experimental findings will likewise be of considerable importance since this would suggest that while at face value the two are attempting to characterize the same or similar cognitive operations, they, in fact, are measuring different functions or at least that there is differential sensitivity in the measurement of each.

B Particular

Since the present research is an ititial venture into the area, the scope of the study must be kept within manageable limits. Therefore, the general problem presented in section A of this chapter was reduced basically to an experimental investigation of the relationship between a sampling of Loyola instruments used in the assessment of the problem solving process and selected problems of Jean Piaget employed for a similar purpose. Administering both sets of instruments to the same sample would provide the opportunity for comparison. However, additional knowledge concerning the sample should enhance the possibilities for comparisons as well as aid in their interpretation. For this reason subsamples were defined corresponding to three of the levels of education found in the Zurich school system for students in this particular age range. Basically, these levels of education represent different degrees of academic performance or achievement. Further a standard test of ability was administered with the purpose of further identifying the sampel. These latter two variables provide external criteria for evaluating the results of each approach as well as make possible more detailed levels of analysis.

Additional variables enter the research by virtue of the different types of problems of each approach which are administered. These aspects will be detailed in the section on the description of the instruments; but it can be indicated here that for the Loyola problems this refers to degrees of complexity and the languages of presentation, while for Piaget problem content and level of difficulty is involved.

Previously it has been suggested that the problem of quantification of performance in the Piaget experiments is a major one. Indeed, this issue alone can and has provided material for study. It was therefore beyond the scope of this research. The problem was obviated principally by employing the Piaget results as a means of classification and then conducting the analyses on these classes using as criterion scores either the results of the Loyola problems or the intelligence test. For instance, classes can be established by the stage performance in a particular Piaget experiment and then differences between these classes in terms of performance on either the Loyola problems or the intelligence test can be investigated. It was also intended to compare the factorial composition of the Loyola and intelligence variables for such classes.

Finally, the present study renewed the feeling that certain undesirable aspects remained in existing methods of scoring the Loyola problems. While the existing techniques have proved useful and valuable, they remain open to improvement. Since the present research presented the opportunity for empirically evaluating new possibilities without detriment to the primary objectives, an assessment of two new alternatives was built into the present research.

C Objectives and/or Hypotheses

It is hoped that the foregoing has placed the present research in the proper perspective. Its primary purpose, then, is to serve as an indication or signal of the promise to be found in this particular application of comparative research. The present authors do not expect this research to make possible large additions to the theory of the Loyola approach but rather to make the necessary determination as to the fruitfulness of such research. Once this decision has been taken, more detailed and more specific studies may or may not be indicated.

The following is a summary of the major objectives and/or hypotheses:

1) Determination of a preferred method of scoring the Loyola problems based on the various methods' abilities to distinguish performance on these problems for groups defined by levels of education or quartiles on the intelligence test.

2) Investigation of the sensitivity of the intelligence test in distinguishing levels of education.

3) Investigation of the sensitivity of each Piaget experiment in distinguishing levels of education.

4) Using the preferred measure, the determination of possible differences in performance on the various Loyola ~~problems~~ for groups defined by their stage performance in each Piaget experiment.

5) Investigation of possible differences in performance on the intelligence test for groups defined by their stage performance in each Piaget experiment.

6) Identification of the factorial composition of the combined Loyola and intelligence variables for the total sample.

7) Identification of the factorial composition of the combined Loyola and intelligence variables for groups defined as performing at particular stages in each Piaget experiment, when this is possible.

8) Comparison of the various factor structures if such proves meaningful.

D Related Literature -- Description of the Instruments

Due to the original nature of the research, only literature peculiar to the individual instruments used in this research will be reported here. This is the reason for combining consideration of these two areas.

a. Loyola Approach -- Instruments and Scoring Procedures. As was indicated previously, the Loyola technique had its origins in a very particular problem -- the characterization and assessment of the medical diagnostic process. In subsequent research the problem was extended to the general problem solving situation. New instruments were developed, techniques designed and refined for the evaluation of the process, the instruments themselves modified to make possible rigid control and definition (13, 17, 14).

Crucial to the progress of the research on the problem solving process was the ability to characterize a particular problem (instrument) according to levels of intrinsic and extrinsic difficulty as well as an objective method of evaluation, not dependent, therefore, on norms established by the performance of a group. Intrinsic difficulty refers to the number and type of logical relationships in the problem; extrinsic difficulty, to the mode of presentation or language (concrete, abstract-concrete, or abstract-abstract) in which the problem is presented. The objective method of evaluation is based on the logical relationships (structure or schema) of the problem and the most direct means of manipulating them in obtaining the desired solution (21).

Though the instruments may be of several kinds (16, 20), the typical one consists of the statement of the problem and a series of questions and answers (of varying degrees of relevance) which the subject may choose to reach a solution. The questioner may ask as many questions and in any order that he desires. The questions and their order are recorded for each performance and this sequence is called an "observed tactic". Since the questions and answers involve aspects of the problem related to its logical relationships, a specified number of questions to be asked in a particular order may be objectively defined for each problem. This sequence of questions is called an "ideal tactic". An individual's process, then, is assessed by the correspondence between the observed and ideal tactic.

In this research two levels of intrinsic difficulty are included. The problems identified by the number 31 represent a set of logical relationships that can be described as a double dichotomy or graphically as a tree with two branches, each branch having two limbs. A 2 x 2 contingency table can also be conveniently employed to summarize the logical relationships involved. The other level of intrinsic difficulty represented is identified by the number 35. It is the case of a double trichotomy or, graphically, a tree with three branches and each branch having three limbs. In this case a 3 x 3 contingency table would be appropriate.

Each of the above schemata is "clothed" in all three languages for this study. The concrete language refers to the type of symbolization used in everyday experiences, e.g. a man making a purchase in a store. This language is identified by the letter A. Thus, the double dichotomy expressed in this language is identifiable as 31A. The abstract-concrete language indicates that the problem is presented by the use of abstract symbols, e.g. A's may be P's and Q's. However, it is partly concrete, since the answers to questions that the subject may ask are given in number form. Thus a double trichotomy expressed in this language would be called 35B, and so forth. Finally, the abstract-abstract language indicates that both the problem and the answers are expressed in abstract or algebraic form, elgl there are b P's that are also A's. This language is identified by the letter D.

The objective method of scoring is called the Schema Pulling-Out Method (SPO) (4). This method purports to measure the degree of similarity between the ideal and observed tactic. Considered the notion of similarity is both the identity and order of the individual questions in the comparison of tactics. This technique also makes provision for reorganizing or restructuring during the process, by pulling out the irrelevant questions (hence the name) and thus maximizing the approximation to the ideal tactic and then later penalizing for the irrelevant questions. Even so, when analyzing the mechanics of the scoring procedure, the investigators were not completely satisfied with the relative weight given to the relevancy of the questions of the observed tactic as represented in the final measure of the process. For this reason, a pure relevancy score was devised which consists simply of the ratio of relevant questions to the total number of questions asked by a subject. In this context, relevant questions are defined by the single ideal tactic which best approximates the observed. The denominator of the ratio was never permitted to be less than the number of questions of the ideal tactic in question. This latter qualifications insures that the index is a measure of the degree of total relevancy needed in the problem's solution and not just a measure of ad hoc relevancy, i.e. what proportion of the questions asked were relevant, though this notion is also involved. Thus this measure is primarily a relevancy measure since order of questions is not considered. But, as was indicated, in the authors' opinion the SPO gives too much weight to the aspect of order. The second new method of evaluation, or the third way of evaluating the Loyola problems, consequently proposes a combination of the SPO and REL (relevancy) measures to form a new method (SPOREL) where the SPO and REL measures are given equal weight. It had originally been intended to include consideration of the correctness of the final solution. However, a review of the experimental situation in terms of the control that was possible with respect to the answers recommended discarding this possibility. Also the literature has repeatedly indicated that the final solution is at best an inadequate measure of the process (16, 20, 22).

Finally, a seventh problem was introduced into this research. It is of a different type from the preceding and consists in a complex geometric figure containing 24 areas. The subject's task is to identify a preselected area by making use of the usual set of questions and answers. It is called Problem #42 and was chosen for the study because it was a different type of problem and because the experimental evidence has shown it to be a sensitive measure of the process in a variety of applications (19, 22).

Thus in the present research the variables deriving from the Loyola approach are the seven problems (31A, 31B, 31D, 42, 35A, 35B, and 35D) and the three methods of evaluation (SPO, REL, and SPOREL). Of the latter, one is to be selected as the preferred method for the comparisons involving the Piaget data. Examples of each problem can be found in Appendix I.

Though the literature contains much that is of interest regarding the Loyola approach, as can be seen by the fifty publications of the Loyola Psychometric Laboratory, only that which is particularly germane to the research under consideration will be cited here. For the rest, the reader is referred to a summary of the present theory and applications found in "Thinking and Language" by Rimoldi (15) and "Research Applications of a Technique for the Study of Thinking Processes" by Erdmann (3).

Of particular interest is "Problem Solving in High School and Collete Students" (18) where the evidence indicated that the instruments used in this study were quite sensitive in distinguishing groups classified according to performance on a test of reasoning ability, a standard test of problem solving ability, and academic achievement. This study was performed with an American student sample but no dramatic difference is expected in this area with the Swiss sample. Evidence from this research helped in the selection of instruments for the proposed study.

Two other studies by Vander Woude (25) and Riedel (12) have dealt with the relationships between aptitude tests and the Loyola measure of problem solving performance. Riedel used the Differential Aptitude Test to identify high and low groups and found consistent differences in the Loyola measures, none of which are employed in the present research. Vander Woude employed the Science Research Associates test of the Primary Mental Abilities and failed to find positive evidence for this test as related to the Loyola measures of process. He suggested that this test was perhaps too general a measure to define problem solving ability. Partly on this basis it was decided preferable to analyze the intelligence test employed in this study in terms of its various subtests.

Paiva (10) in a yet unpublished study, factor analyzed 18 Loyola problems included among which were all the problems of the proposed study. She found three factors which she described as being factors of abstraction, difficulty, and "perceptual verbo-concreteness". According to her findings, the present authors can expect the first and third factors to be defined on the basis of the problems selected for the proposed research. According to her findings, problems 31A, 35A, and 42 would define the perceptual verbo-concrete factor, and problems 31B, 31D, 35B, and 35D, the abstraction factor. The results of Paiva reported here are based on the SPO method of scoring. However, she also used another method, not one of those proposed for exploration, which yielded quite the same structure.

Finally, the value and usefulness of the Schema Pulling-Out (SPO) method of evaluating performance on the Loyola problems is attested to by Erdmann (4). Donnelly (2) studied this method in relation to an application of information theory and found no general differences despite theoretically different bases. This finding is important in the decision of methods for the evaluation of problem 42.

b. Piaget Approach. The work of the Swiss psychologist Jean Piaget has received world wide attention and his publications are quite generally available so that only essentially relevant aspects will be detailed here. An excellent presentation of his pertinent material can be found in English in Flavell's book, The Developmental Psychology of Jean Piaget (5).

In the course of the development of his theory, Piaget has employed various experimental situations for the purpose of bringing evidence to bear on his theory and to exemplify certain of its aspects. These experiments which may be described as problem solving situations were designed to make possible the identification of the cognitive operations involved. Piaget was able to classify the performance in a particular experiment according to one of his stages of cognitive development on the basis of the operations he was able to identify. The present authors, in consultation with Dr. Hardi Fischer, a former student and expert on Piaget, selected three such experiments judged appropriate for the present research. They involve areas relating to combinatorial theory, probability, and equilibrium. Respectively, the authors have given them the names, Combinations, Probability, and Balance. Detailed information regarding these three experiments can be found in two books, the first two in La Geneŝe de L'idée de Hasard Chez L'enfant by Piaget and Inhelder (11), and the last in The Growth of Logical Thinking from Childhood to Adolescence by Inhelder and Piaget (8).

Before beginning a detailed exposition of the individual problems, certain general considerations concerning their application to this research will be presented. It was not possible, considering the purposes of the present research, to duplicate Piaget's experimental situation. That is, Piaget and his associates use a very loosely structured presentation of the experiments. This is seen necessary by him because he feels it is appropriate to adapt the particular experiment to the individual subject, who, consequently, serves as a guide to the way in which the material is presented as well as to the content of that material. This is consonant with his purpose of diagnosing the cognitive development achieved by the subject under study. On the other hand, this restricts the possibilities for comparisons between subjects due to the lack of a standardized presentation of stimuli. Since this latter point is of crucial importance to the present study, it was necessary to attempt a standardized form of presentation for the Piaget experiments. This was of considerable help also in training the several experimenters who participated in the collection of the Piaget data. Therefore, each of the selected experiments was studied by means of the description of the experiment itself and the corresponding protocols found in the Piaget literature, and on this basis a standardized presentation for each experiment was formulated. While the attempt was made to adhere as closely as the situation permitted to the procedure of Piaget, modifications were of necessity introduced. These occur both in the format of the experiment and in the criteria for its evaluation. At times, it must be confessed, the pertinent information from the literature was found too meager to solve the various problems that arose in connection with the present use of the Piaget experiments. This seems to have been the experience of others when faced with a similar situation (9). Therefore, the degree of approximation to the Piagetian procedure is an important consideration in the evaluation of the implications of this comparative research.

In all the experiments used, the interview aspect of the Piaget presentation was maintained, but now this interview was no longer the clinical interview of Piaget, but rather a structured interview situation, in which the examiner followed guidelines for the presentation of stimuli and the collection of information regarding the subjects' manipulation of the stimuli. Copies of the forms as employed by the examiners for each experiment are found in Appendix II.

i. Combinations Experiment. This experiment consisted in the presentation of six sets of chips, each set of a different color. The subject's task was to identify the pairs in the combinations of six things taken two at a time. In order to facilitate the subject's task of specifying the composition of the 15 different pairs, the problem was presented by means of a concrete illustration.

Shortly after beginning his work on the problem, the subject was asked if he had a plan in mind to guide his efforts. He was then permitted to work uninterruptedly until he felt he had reached a solution. He was then requested to make explicit verbally the procedure he followed. He was also asked if he could state in a quantifiable way the number of pairs required. Further, he was asked if he was satisfied with his work and finally if he would like to do it differently, if given another opportunity. In addition to this information, the experimenter made a written record of other relevant activity.

The purpose of the questions was to obtain additional information about the subject's performance, and of equal importance, to verify possible inferences from his behavior. Specifically, the first question attempts to determine if the subject had a preconceived or "anticipated" plan of action or whether he was proceeding through trial and error. The second question dealt with his awareness of his *modus operandi*. The third question related to his ability to formulate the present problem in a quantifiable or quasi-formula fashion. The fourth and last questions attempted to determine the subject's satisfaction with his solution as well as whether he felt he had learned through his manipulations and thus wanted to suggest a subjectively superior approach.

In analyzing a particular performance, special attention was given to: 1) whether the subject proposed a systematic approach, 2) what, if any, type of system was suggested, 3) whether the subject was capable of applying and executing his plan, 4) whether he was able to quantify the problem, and if so how, 5) whether those, beginning without any plan or without the preferred plan, were able to empirically derive the preferred one as a result of their experience.

Depending upon the information obtained above, a subject's performance was classified into one of the stages as defined by the criteria presented below:

Stage I - No system proposed. Purely trial and error procedure with no visible relations in successive pairs.

Stage II A - The advent of primitive systems where they are characterized as depending upon the physical locations of the chips as presented to the subject. Very frequently these systems break down after the identification of but a few pairs, and the situation becomes too confusing to the subject for him to follow it through to conclusion.

Stage II B - Subject still begins with primitive system, but either during his efforts reverses his approach to coincide with the preferred or proper plan, or is able to suggest the proper plan after empirically determining the necessary pairs.

Stage III A - Here the subject anticipates the proper system, rather routinely executes it and is able to quantify the problem in an additive fashion. If either the anticipation or the quantification aspect is absent, the performance was classified in the previous stage, i.e. II B.

Stage III B - The same characteristics describe performance in this stage as in Stage III A, with the added attribute that the quantification must be multiplicative in nature. That is, instead of the subject recognizing the lawful characteristics of $5+4+3+2+1=15$ as a way of describing his groups of pairs as in Stage III A, he determines his solution in the usual combinatorial way, i.e. $(6x5)/2=15$ pairs.

In this and the two experiments which follow, much more lengthy descriptions of typical performances at the various stages have been provided by Piaget, but these descriptions do not always clearly differentiate stage performance nor do they provide workable criteria for evaluating a large sample of protocols. The above criteria were practical solutions worked out using indications from Piaget's descriptions of the various stages, together with his own evaluations of relevant protocols. This latter comment is relevant to the criteria to be cited for the two remaining experiments also.

ii. Probability Experiment. In this experiment the subject was shown two different types of chips, one solid yellow and the other checkered. He was told that two piles would be formed from both types of chips and that he was to indicate the pile from which he would prefer to make one draw if he wished to draw a checkered chip. He was then presented with nine such choices (items) in which the composition and size of the piles varied. Items were of various kinds: one in which no term varied, others in which one term varied, and still others in which more than one term varied. For example, the item of the first type was 4/8 // 4/8 in which each pile had four checkered and four yellow chips, or reading the numerically symbolized designation--each pile had four checkered chips in a total of eight. The second type of item can be exemplified by 2/4 // 2/6, in which the number of checkered chips is the same for each pile and the number of solid yellow, different (thus the totals must of necessity be different). Finally, an item of the third type was 4/7 // 2/3. In the first pile there were 4 checkered chips and 3 yellow chips (total of seven) and in the second pile 2 checkered and 1 yellow. With this classification of variant terms Piaget's exposition has been followed.

No specific questions were formulated except that for each item the subject was requested to give his rationale for the choice which he made.

With respect to these rationales, specific attention was devoted to analyzing their salient features. Whether the subject was able to identify or isolate important variables, whether he attempted any quantification of these variables and of what type the quantification was, the number of variables given consideration, and whether this consideration was adapted to the problem at hand, are examples of some of these features.

On the basis of the evidence from this type of analysis, as well as certain other indications provided by Piaget, the following criteria were adopted to establish performance at a given stage:

Stage I A - The reasoning advanced by the subject for his decisions involved no quantification even of the kind where an irrelevant variable was quantified and compared. In this context quantification is not defined as a comparison of an overall impression of size but rather implies some sort of frequency comparison.

Stage I B - Reasoning is still not particularly clear as to isolating important variables - typical of this stage was a decision of equality for the two piles where the basis of judgment was a term which was invariant.

Stage II A - Beginning of the isolation of relevant variables. Typically one relevant variable is selected as the basis of judgment for all of the items regardless of the appropriateness of the particular variable to a given item.

Stage II B - Subject still employs only one variable as basis for decision, but systematically changes its identity to correspond with that best fitting the situation.

Stage III A - For the first time a part to whole consideration is evident. However in this substage, it is of a perceptual nature. Or the rationale may involve the simultaneous weighing of two variant terms on a frequency basis rather than ratio basis, but yet subject gives evidence of considering the relationship between the variant terms for each sample and the relationship between these relations for both samples.

Stage III B - Subjects present ratios expressed either as fractions or percentages for their comparison and decision regarding a given item.

In several of the above stages, Piaget has offered specific types of behavior typical for a given substage performance, but these criteria were not amenable to rigid application such that in cases where they suggested contradictory indications, the issue was resolved by reliance on the generalized description of the substage. Also, as was emphasized by Piaget, overall performance on all of the items was used as the means for evaluation rather than performance on one or two isolated items.

iii. Balance Experiment. In this experiment the subject was shown a primitive balance, consisting of a wooden bar suspended at the middle. Twelve holes, with equal distances between, were bored into each side. The holes were numbered consecutively from the axis and used to hang weights of various sizes (50, 100, and 200 grs.) at various distances from the middle. The appartus was presented without any weights on the bar to assure the subject that it was a legitimate balance and also to demonstrate the situation he was to reproduce, but with weights hanging from the bar. The subject was then informed that though he now saw the balance in equilibrium, weights would be hung on the bar by the experimenter which may destroy the equilibrium. It was then his task to restore the equilibrium by adjusting the weights. There then followed six different situations in which he was to perform this task. In the actual presentation of a given situation (problem) the experimenter held the bar level while attaching the various weights and before releasing it asked the subject to anticipate the result, i.e. whether equilibrium would be maintained and, if not, the direction the bar would move. The subject was then permitted to work uninterruptedly until he had achieved equilibrium. At which point, he was asked to illucidate his movements which had been recorded by the experimenter. The actual values of the weights were not disclosed to the subject unless he specifically requested them. However, these values had been stamped onto the weights by the manufacturer in a fairly conspicuous location.

The problems presented represented various degrees of complexity, e.g. one weight on each side of the same magnitude at the same distance from the middle (position), one weight on each side of the same magnitude at unequal distances, one weight on each side of different magnitudes in the same position, one weight on each side of different magnitudes in different positions, two weights on each side with one on each side of the same magnitude but all in different positions, and finally, one weight on one side and three on the other where the single weight was of the same magnitude as the sum of the three and all in the same positions.

In these problems special attention was focused on these aspects of the subjects' responses: 1) whether the subject correctly anticipated the resultant of hanging the various weights, 2) whether the subject's movements in attempting to achieve equilibrium could be termed, in general, purposeful or in the direction best suited for achieving equilibrium, 3) whether, instead, these movements were trial and error, no purposeful movements inferable, 4) whether the subject's movements were successive approximations in the proper direction or whether there was an exact and correct location of the weights, 5) whether the subject had as the basis for his adjustments only one variable (weight or distance) or whether he used a combination of the two and their correspondence, 6) finally, whether this law of correspondence between weight and distance was appreciated qualitatively or quantitatively.

Using the inquiry into the above issues as points of reference, a particular performance was evaluated at a given stage according to the following criteria:

Stage I A - Subject typically fails to distinguish his actions from those of the apparatus. He may try to achieve balance by holding the bar level and appears satisfied with that solution. He does not seem to appreciate that equlibrium involves distribution of weights or, if he does, he is generally unconcerned with their distances from the axis.

Stage I B - Better integration of intuitions in the direction of compensation of weights. Subject seems to understand that weights are needed on both sides and that these should be approximately equal. There is progress here in the tendency toward symmetry, both with weights and distances, but no consideration for the correspondence between the two. He can not systematically handle certain problems of which the subject in Stage II A is capable (see next substage).

Stage II A - This type of subject is capable of equalizing and adding weights exactly, and adding distances and making them symmetrical. He therefore systematically solves problems involving two equal weights at equal distances, two equal weights at unequal distances, two unequal weights at equal distances, and the substitution of one weight for an equivalent set of others at equal distances. However, he cannot coordinate unequal weights at unequal distances and so is not capable of the general inference that a small weight at a great distance can balance a large weight at a small distance. When this situation is obtained by trial and error, inversion of the relations from one side to the other is not possible.

Stage II B - This subject is capable of making the inversion mentioned at the end of Substage II A, in fact can solve all the problems in a reasoned and purposeful way. Yet his appreciation of the coordination between weight and distance is qualitative and not quantitative, excepting an occasional two to one relationship. Thus he can state in a general manner that a small weight at a large distance can compensate a large weight at a small distance and his movements are governed accordingly.

Stage III A - In this category falls the performance of a subject who gives evidence of being able to predict results correctly for all problems. His efforts, even on the more complex problems, involve little hesitancy and are not characteristic of the type of behavior described as trial and error or successive approximation. A type of quantification is indicated that goes beyond simple two to one relationships. His appreciation of the law of correspondence between weight and distance is refined to the extent that he exhibits facility even in the more complex problems.

As was noted in the previous experiment, a generalized evaluation of performance on all the problems rather than performance in isolated instances served as the basis for stage placement.

Three main considerations account for the lack of literature pertinent to the present research. The first, as Flavell indicates, is that progress in the standardization or psychometrization of Piaget's experiments is still in its infancy, such that studies bearing on the relationship between Piaget's experiments and fields such as general intellectual development, special scholastic aptitudes, etc., are apparently non-existent (5). Further, because of this lack of "standardized experiments," the individual applications vary considerably, making generalization of the findings tenuous if not meaningless. Secondly, few studies of any type have been performed with subjects in a comparable age range. The usual upper limit for such research appears to be about 12 years. Finally, each content area or even each specific experiment must be considered in itself and then the other experimental features of its employment must be relevant before implications for this research are feasible.

c.) Intelligence Structure Test (Intelligenz-Struktur Test). This test was developed by Rudolf Amthauer and norms have been developed for its use in Germany. The purpose of the test, as indicated by its title, is to assess performance in specialized areas within the general area of intelligence. This test has been adopted for use, with little change in content, in the German-speaking Zürich area, and at present local norms are being established by the Swiss Association for Applied Psychology. The test consists of nine subtests, four of which purport to measure verbal ability; two, quantitative ability; two, spatial ability; and one, memory. The test is published by Verlag für Psychologie, C. J. Hogrefe, Göttingen, West Germany. Each of the individual subtests will now be briefly described as to content. They will be described in the order presented.

1. Sentence Completion (SE). A statement is proposed and the proper word must be selected to complete it. It attempts to assess characteristics such as common sense, sense of reality, thinking in a concrete practical way, and with teenagers, independent thinking.

2. Word Choice (WA). Of five words presented in a given item, the word not fitting the class must be identified. This test purports to measure inductive lingual thinking, or "feeling for language," as well as a grasp for concepts and should provide a norm for facility with common concepts.

3. Analogies (AN). The usual type of analogy item is presented with one of the four elements missing. The proper element to fill the vacancy must be selected from a set of five possibilities. Performance should reflect ability for combining and flexibility in thinking, realization of relations, and compulsiveness or precision in thought.

4. Communalities (GE). Two particular elements of a class are presented and the common class name must be supplied. This test attempts to measure ability for abstraction, concept construction, and verbal expression.

5. Arithmetic Problems (RA). Situational (word) problems are presented which the subject must solve. This claims to evaluate practical arithmetic thinking.

6. Number Series (ZR). Sequences of numbers in which the missing number is to be inferred from an underlying rationale. Inductive thinking with numbers and theoretically oriented arithmetic thinking are the characteristics apparently tapped by this test.

7. Figure Choice (FA). Scrambled parts of a geometric figure are presented which the subject must organize to identify the totality as one of the examples presented in conjunction. This test purports to measure ability for representational imagination, for wealth of representation, for wholistic thinking based on

perception, and for "synthetic thinking."

8. Cube Problems (WÜ). Five different cubes are presented as models and each test item (a cube) must be identified as one of the models though the latter appears in a different position. Performance on this test purportedly reflects ability for spatial representation and analytic thinking.

9. Memory (ME). Five class names and five elements of each are presented and subject is asked to memorize these in three minutes. Recollection is tested by the presentation of the initial letter of an element which then must be identified as belonging to one of the five classes which are re-presented. This test attempts to give an index of the ability to memorize and the capacity to retain learned words, and can be used as evidence for a measure of concentration.

Urlaub (24) conducted a factor analysis of the Amthauer battery using the German form with German subjects. She identified two factors, the first of which may be likened to Spearman's "g" factor for which she observed loadings on all subtests; the second factor composed the two number tests and the memory test. On this basis, one might expect the Amthauer battery to be the source of two factors for the present research.

II Methods

A. Subjects

The subjects employed in this research were selected from schools representing three educational levels located in Zürich and the surrounding area. The educational levels were Gymnasium, Sekundarschule, and Realschule. The Gymnasium represents the highest level of academic performance and students at this level generally are preparing for a professional future. The Sekundarschule represents the second highest level and its students generally are not preparing for university training, but for what may be generally classed as "white collar" positions. Finally, the lowest level under study is the Realschule, whose students intend to become craftsmen or tradesmen. Both male and female students were used in each level and the total number of subjects studied from each level was 92 from the Gymnasium, 80 from the Sekundarschule, and 92 from the Realschule. Within a particular level no effort was made toward further selection such that availibility was the primary criterion for selection. Additional subjects were partially tested from each level, but they were not studied because there were not sufficient data for the analyses planned. Of the 264 subjects from all three levels, it was only possible to obtain records of Piaget performance on 185 which were distributed almost equally among the three levels. The remaining 79 students yielded complete information with respect to the Loyola problem solving tasks and the Amthauer intelligence test. Thus those analyses involving only Amthauer and Loyola comparisons made use of the larger sample and those involving the Piaget data obviously were limited to the smaller sample (N=185).

The subjects were all from an urban area of German-speaking Switzerland, but cannot be considered representative of the latter portion of Switzerland since only one urban area was tested and no work was done with the rural counterpart. Further, the reader should be cautioned that with the exception of the Freies Gymnasium in Zürich, all testing was performed in the public school system.

The age range was between 13 and 16 years for all levels.

B. Instruments

A previous section dealt in detail with the three major types of instruments utilized. Therefore, this section will be limited to rather technical aspects of the application of those instruments.

1.) The seven Loyola problems (31A, 31B, 31D, 42, 35A, 35B, 35D) were presented in the order listed in every case. They were administered in group form to individual classes whose sizes varied from about 20 to 25. Two consecutive class periods, or about two hours, were allowed for the completion of the seven problems. Every student was permitted to work at his own rate. Experience with the actual testing and piloting sessions indicated this length of time sufficient. While not all students yielded records on the final problems, evidence from the experimental situation indicated this was not due to lack of time but rather to inability to handle the more difficult problems.

The subjects were first given a sheet of written instructions (Appendix I) and a sample problem (Appendix I). Questions were elicited and the experimenter then orally repeated that the subjects should read the problem and all the questions before deciding to select a particular one and that they should not ask more questions than they really needed for the solution.

The instructions, the sample problem, and the seven problems were piloted with several Sekundarschule classes (the middle range level of academic performance) from an independent source to insure the absence of ambiguities, mistakes in translation, technical errors in reproduction and administration, etc., as far as possible. During this preliminary work an Oberschule class (the lowest level of academic performance in the Zurich school system) was tested and found to be on the whole incapable of yielding meaningful data on the Loyola instruments. The experimental stimuli appeared to be too complex for them to handle meaningfully. This finding resulted in the exclusion of this level from consideration in the present research. As a result of the precautions suggested by the piloting sessions, the testing with the Loyola problems encountered little difficulty. Prior to the pilot work, each Loyola problem was translated into German and then reanalyzed in terms of the original to avoid the introduction of subtle changes through translation.

After the completion of the orientation phase of the Loyola testing, the first problem was distributed to all students. Thereafter successive problems were made available to the student when he had completed the previous one.

The performances were scored according to the three ways indicated earlier, i.e. SPO, REL, and SPOREL. In order to make these measures comparable for analysis, each was expressed as the ratio of the observed to the maximum possible score. Each protocol was scored by two persons independently to uncover possible errors in this process.

2.) The Amthauer Intelligenz Struktur Test was administered in group form according to the instructions of the accompanying manual. Calculations in scoring were also controlled by independent checking. Since norms are not yet available for the Swiss population, the raw scores were utilized in the analysis.

3.) The Piaget experiments were administered individually and a typical session for all three experiments lasted between 25 and 35 minutes. As was indicated earlier, each experiment had to be reconstructed on the basis of the information available, and therefore considerable piloting was necessary to determine the workability of the reconstructed problem, the manner of its presentation, the information it yielded, and the facility with which performance on it could be classified, among other considerations. This piloting, then, was used to establish a structured presentation of each experiment so that some control could be maintained on the stimuli and so it was feasible to use different experimenters in its presentation.

The experiments were administered in the order in which they were described in the previous section, viz. Combinations, Probability, and Balance. Since the protocols were taken in Swiss German, it was not always possible to have a completely independent evaluation of each performance. Nevertheless this end was pursued as far as the limitations of the present project permitted, and every evaluation was the result of a consensus from two scorers.

A few general remarks remain concerning the three phases of testing. The order followed was Amthauer, Loyola, and Piaget. No training effect was anticipated between phases but this sequence was maintained nevertheless. A total of six experimenters were involved in the testing of the three phases. However, only four of these administered the Piaget experiments and while this is seen as a variable of possible influence, efforts to maintain certain controls were undergone with the attempt at a standardized administration of the Piaget experiments.

The testing was inaugerated in January and extended through May.

It was indicated that the sequence of Loyola problems was constant for every subject. It might be thought that a preferable approach would have been to randomize systematically their presentation to offset training effects and thus make possible a problem by problem comparison for various groups without consideration of these effects. However, since the primary objective of the research was relating Loyola with Piaget performance, and since the groups could only be specified by performance on the Piaget experiments, it was impossible to predict beforehand the composition of these groups in order to equalize training effects on the Loyola problems. It was thus decided to maintain a constant order of administration for the Loyola problems to insure some control over such training.

C. Design

As can be inferred from an inspection of the objectives and/or hypotheses presented earlier, this research is primarily a mapping out type of investigation. On these bases the various instruments were administered in the order specified immediately above to the same sample of subjects. Ordinarily a covariance type of analysis would be indicated but due to difficulties in quantifying performance on the Piaget experiments, an alternative approach became necessary. This generally involved the identification of classes or groups of performance in one variable and the observation of corresponding change or lack of it in the other variables. For example, performance on a Piaget experiment could be evaluated in terms of a stage of intellectual development and then possible differences between these stages for performance on the Loyola problems and the Amthauer intelligence test investigated. This is the information sought in objectives #4 and #5.

At this point each objective will be considered in turn and the design, employed to satisfy its aims, made explicit.

Objective #1 involved the determination of the preferred method of scoring the Loyola problems among the Schema Pulling-Out Method (SPO), the Relevancy Method (REL), and the combination (simple average) of the two (SPOREL). This was pursued in two ways: first, by using the Amthauer measures of intelligence to establish quartiles through all levels of education and then to observe whether there was a differential sensitivity of a scoring method for distinguishing these quartiles; second, by using only the level of education to which a subject belonged as the means of establishing criterion groups, and then to study possible differences in a scoring method's ability to distinguish these groups.

The first approach was executed by employing a two-factor factorial analysis of variance design with repeated measures on the second factor. The levels of the first factor were the four quartiles as established by performance on an Amthauer subtest. The three levels of the second factor corresponded to the three methods of scoring, viz. SPO, REL, and SPOREL. This 4 x 3 design was repeated for each Amthauer subtest and for each Loyola problem such that there were 63 of these analyses. It should be noted here that all terminology related to anlayses of variance is that suggested by B. J. Winer (26). The size of the sample for this analysis was N=264, N=66 for each quartile.

The second way involved the use of a 3 x 3 design with repeated measures on the second factor. The first factor was defined by the three levels of education investigated, viz. Gymnasium, Sekundarschule, and Realschule. The second was again the three methods of scoring the Loyola problems. This design was repeated 7 times, once for each Loyola problem. The size of the sample in this case was N=240, N=80 for each level of education.

The second objective dealt with the effectiveness of the Amthauer test in distinguishing levels of education. This was accomplished by again identifying groups according to levels of education and then determining possible differences between levels on each Amthauer subtest. The vehicle for this analysis was an analysis of variance, single factor design with three levels in that factor. This design was repeated nine times, once for each subtest. The total sample size was again N=240, with N=80 for each level of education. Here as before 80 Ss were selected randomly from each the Gymnasium and the Realschule.

The third objective related to the sensitivity of the Piaget results in distinguishing levels of education. This involves a frequency comparison of the number of subjects within each level of education falling into a stage classification on a given Piaget experiment. The chi square test for a 3 x 3 contingency table was utilized for this analysis. The first dimension is the three levels of education and the second, the three major stages of intellectual development in a Piaget experiment. This design was repeated three times, once for each Piaget experiment. The sample for this analysis was N=185.

Objective #4 concerns possible differences between the performances on Loyola problems of groups classified at the three major stages on a given Piaget experiment. Since six of the Loyola problems can be classified according to levels of intrinsic and extrinsic difficulty, together with the Piaget variable there were three factors to this analysis of variance design. The design was a 3 x 3 x 2 factorial design with repeated measures on the last two factors. The first factor is composed of three levels which are the three major stage classifications for a given Piaget experiment. The second factor is the language factor for the Loyola problems and has three levels, i. e. language A, language B, and language D as defined earlier. This is the factor of extrinsic difficulty. In the third factor two levels of intrinsic difficulty are represented, viz. 31 and 35 series problems. The total sample was N=185 for the entire design but the distribution of the elements of the sample depended upon the stage classification of subjects indicated by the Piaget experiment under study. This design was then repeated three times for each Piaget experiment. In each case a least squares solution was applied because of the different size subsamples in the experiment and since these different sizes are related to the variables under study. The preferred method of scoring as determined in the previous objectives provides the criterion score for the Loyola problems.

The seventh Loyola problem and its relationship to Piaget performance was analyzed by a single factor design where the levels of the factor represented are the major stages and the criterion measure is once again that determined to be preferred for Problem 42 by previous analyses. Also the sample size is the same as found in the 3 x 3 x 2 design. This single factor design was repeated for the three Piaget experiments.

Objective #5 treated the comparison of Piaget performance and Amthauer performance. Here a single factor design was employed where the three levels of the factor represented corresponded to the major stages of intellectual development. This design was repeated for each Amthauer subtest and for each Piaget experiment, thus yielding a total of 27 applications. The size of the sample is N=185 and the subsamples, as indicated above.

Objective #6 indicated a factor analysis of the combined Loyola and Amthauer variables. The purpose of this analysis was to provide the norm or the factor structure with which succeeding analyses were to be compared. The sample size for this analysis is N=264.

Objectives #7 and #8 can be considered together. They involved the identification of the factorial composition of the combined Loyola and Amthauer batteries for various individual groups. The composition of these groups depended upon the stage performance in a particular Piaget experiment. Once the factorial compositions of the indicated variables was identified for the various individual groups, then a comparison of these factor structures among themselves and together with that for the normative group was suggested. Obviously the sizes of the various groups depended on the performances that could be classified as falling into a particular stage in a given problem.

The purpose of such a comparison of factor structures was to determine whether, when Piaget speaks of different cognitive functions being exemplified at different stages of development, such differences would be reflected by the measures of cognition involved in the Loyola and Amthauer batteries as indicated by their factorial composition. Or to put it another way, are the factor structures of the combined Loyola and Amthauer batteries invariant with respect to the different stages of cognitive development as postulated by Piaget in his experiments which have been selected for study?

All factor analyses were calculated according to the principal axes solution and rotated to orthogonal "simple structure" by means of the varimax technique. Communalities were estimated by selecting the maximum correlation in the column. Previous experience of the authors has shown this estimate to be as trustworthy as the more involved methods of obtaining such estimates. While the authors would have preferred to rotate each orthogonal solution to oblique simple structure, such a possibility could not be realistically entertained under the circumstances of the present research.

All major phases of the data analysis were conducted through the facilities of Bull-Gereral Electric offices in Zürich with the cooperation and assistance of Mr. Henry Keller. Mr. Keller wrote and tested the various programs needed and supervised the running of the data on the computer. The programs were further checked for accuracy by the authors using internal checks of consistency.

III Results and Findings

The results and their analysis will be presented according to the logical sequence implicit in the presentation of the objectives.

The first phase therefore involved the selection of a preferred method of scoring the Loyola problems. For this purpose 63 4 x 3 analyses of variance were performed to determine the differential sensitivity of the three proposed methods of scoring to quartile differences in each Amthauer subtest for each Loyola problem. Due to the large number of analyses, the usual summary of the analysis of variance for each of the 63 will appear only in Appendix III. In the text Tables 1, 2 and 3 are summary tables which present the significance decisions corresponding to the main effects of factor A (quartiles), of factor B (scoring methods), and the main interaction effects AB, respectively, for each of the 63 applications.

Table 1

Summary of Significance Decisions for Main Effects of Factor A (Quartiles) for All Possible Combinations of Loyola Problems and Amthauer Subtests

A (Quartiles)
Loyola Problems

Subtests	31A	31B	31D	42	35A	35B	35D
1st	.01	.01	.05	.05	.01	.01	.01
2nd	.01	.01	.01	.01	.01	.01	.01
3rd	.01	.01	.01	.01	.01	.01	.01
4th	.01	.01	.01	.01	.01	.01	.01
5th	.01	.01	.01	.05	.01	.01	.01
6th	.01	.01	.01	.01	.01	.01	.01
7th	.01	NS	NS	NS	.01	.01	.01
8th	.01	.01	NS	NS	.01	.01	.01
9th	.01	.01	.01	NS	.01	.05	NS

An inspection of Table 1 reveals only seven non-significant decisions with respect to quartile differences for the nine subtests where the seven Loyola problems provided the criterion scores. (The usual summaries of the analysis of variance for these designs and those that follow can be found in Appendix III.) Thus, in general, it is strongly indicated that classification on a quartile basis according to subtests of the Amthauer intelligence test can be used as a criterion for performance on the Loyola problems. This is especially true for the first six Amthauer subtests. In terms of the last three subtests, the same consistent effectiveness does not hold, especially for Loyola problem 42, and, to a lesser extent, 31D. Single instances of the inability of a Loyola problem to distinguish quartiles are found for 31B in the seventh subtest and for 35D in the ninth subtest. Looking at the situation from from the standpoint of Amthauer subtests, on the other hand, it can be observed that quartile divisions in the seventh subtest cannot be used to differentiate performance on Loyola problems 31B, 31D, and 42; in the eighth subtest, on problems 31D and 42; and in the ninth subtest, on problems 42 and 35D.

If there exists any systematic findings in respect to a lack of relationship between Loyola problems and Amthauer subtests, it is most probably found in the case of the seventh Amthauer subtest and three problems mentioned above, or, from the other point of view, in the case of problem 42 and the last three subtests. Assuming these findings require interpretation, one will be offered. Regarding the seventh subtest it will be remembered that it purports to measure synthetic thinking. The Loyola problems where such thinking, according to the Amthauer, is not found were simple abstract problems and the geometric problem. It can be argued that problem 42 does not involve synthetic thinking since the solution is obtained primarily by a process of elimination of areas. Problems 31B and 31D do not involve the necessity for synthetic thinking since they already appear in abstract form and since they only involve dichotomies. To solve a concrete problem or an abstract one of greater complexity would thus seem to require more thinking involving synthesis. On the other hand, perhaps a more plausible explanation may be that synthetic thinking is involved in these problems but not to the extent that the Amthauer measure is sensitive to it.

Looking at problem 42 in relation to subtests 7, 8, and 9, which attempt to measure respectively synthetic thinking, analytic thinking, and memory and/or concentration, it seems possible that these elements are not so typical of a process that only requires elimination of possible alternatives until only one remains.

An observation should be made with respect to the ability of the first six subrests to define performance on the seven Loyola problems. While in every case, quartiles are significantly distinguished, this does not mean that each quartile is significantly different from all others. In fact such is obviously not the case from an inspection of the means. Further, it is not implied that the first quartile always represents the poorest performance on the Loyola problems, the second quartile, the next poorest, and so forth. Inversions are, in fact, in evidence; however it can safely be stated that following a median division, the expected relationship is systematically observed.

The quartile differences noted in the analyses of variance were based on the average of the three ways of scoring each problem. But this average is identical to the SPOREL method of scoring. Thus all implications of the findings of the main effects of factor A can be maintained whether the basis for measuring performance on the Loyola problems is an average of the three procedures tested or the SPOREL method alone.

This leads to a consideration of the main effects of scoring methods or factor B. In every instance differences were noted between the three scoring methods as seen in Table 2.

Table 2

Summary of Significance Decisions for Main Effects of Factor B (Scoring Methods) for All Possible Combinations of Loyola Problems and Amthauer Subtests

B (Scoring Methods)
Loyola Problems

Subtests	31A	31B	31D	42	35A	35B	35D
1st	.01	.01	.01	.01	.01	.01	.01
2nd	.01	.01	.01	.01	.01	.01	.01
3rd	.01	.01	.01	.01	.01	.01	.01
4th	.01	.01	.01	.01	.01	.01	.01
5th	.01	.01	.01	.01	.01	.01	.01
6th	.01	.01	.01	.01	.01	.01	.01
7th	.01	.01	.01	.01	.01	.01	.01
8th	.01	.01	.01	.01	.01	.01	.01
9th	.01	.01	.01	.01	.01	.01	.01

This is not so surprising considering that the various methods were introduced because they were thought to be measuring different aspects of the problem solving process. However, what is surprising, is the results found in Table 3 or the interaction effects.

Table 3

Summary of Significance Decisions for
Interactions (Quartiles by Scoring Methods) for
All Possible Combinations of Loyola Problems and Amthauer Subtests

AB (Interactions)
Loyola Problems

Subtests	31A	31B	31D	42	35A	35B	35D
1st	NS	NS	NS	NS	NS	NS	NS
2nd	NS	NS	NS	NS	NS	NS	NS
3rd	NS	NS	NS	NS	NS	NS	NS
4th	NS	.05	NS	NS	NS	.05	NS
5th	NS	NS	NS	NS	NS	.05	NS
6th	NS	NS	NS	NS	NS	NS	.01
7th	NS	NS	NS	NS	NS	.05	NS
8th	NS	NS	.05	NS	NS	.01	NS
9th	.01	NS	NS	NS	NS	NS	NS

Table 3 indicates that only in 8 out of 63 cases were the interactions found to be significant. This indicates a very high degree of similarity among the three methods. That is, in 55 cases the measures can be seen to yield practically parallel profiles. A typical set of profiles is presented in Figure 1.

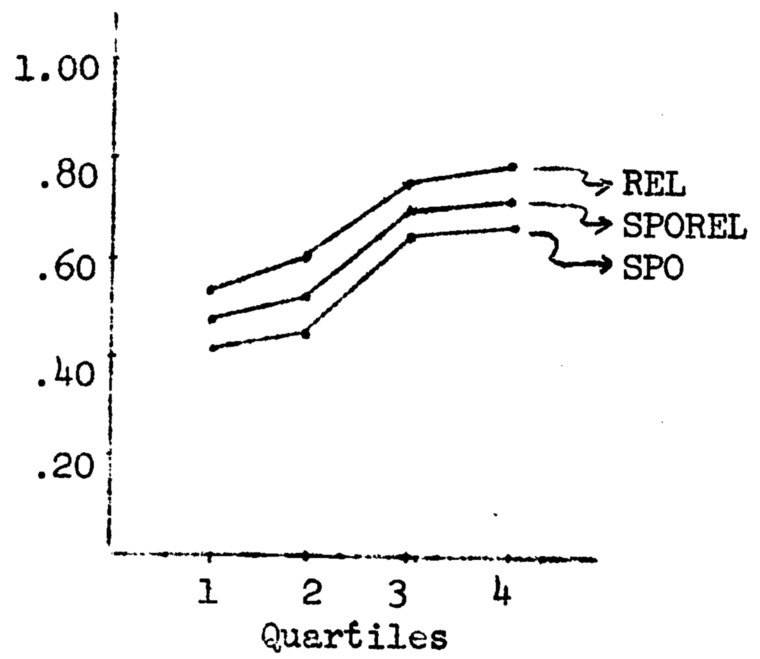


Figure 1

Profiles of Scoring Methods by Quartiles for the Non-significant
Interaction in the Combination of
Loyola Problem 31A and First Amthauer Subtest

Insepcting this figure indicates that the REL measures yield the highest values and the SPO, the lowest. Because by definition the SPOREL is an average of the two, it will always yield intermediate values. Consequently, due to the nature of the findings (the parallelism of the profiles) further special attention to the SPOREL method does not have sufficient merit.

However, the fact that so generally the profiles generated by the SPO and REL methods are parallel is quite interesting. This seems to indicate that while each method, upon theoretical analysis, emphasizes different aspects of the process, these two aspects in general provide parallel information on the process. More specifically, while the pure relevancy measure yields consistently higher values, these values show a very high relationship to those of the SPO method. The latter tends to emphasize order over relevancy, i.e. a relevant question asked out of the proper order receives no value. Therefore, apparently theoretical differences have no verification in the experimental evidence which shows that, in 51 of the 63 possible situations, all methods distinguish equally well quartile differences. This conclusion is possible from a comparison of the information contained in Tables 1 and 3.

Thus, in terms of selecting a preferred means for evaluating performance on the Loyola problems, no obvious advantage accompanies the selection of one particular method when using the Amthauer as the basis for establishing criterion groups. External knowledge then, must serve as the basis for selection of a preferred method. Accordingly the SPO method was selected because of previous experience and information on the procedure.

With respect to the eight significant interactions in Table 3, it is obvious that in these cases there is a differential sensitivity for the SPO and REL methods to performance on the various Loyola problems concerned. An analysis of the plots of the interactions indicates most of the interactions come about because of the loss or lessening of the constant differences between scoring methods as noted in the non-significant instances. For example, the reader is referred to a typical example of a significant interaction presented as Figure 2.

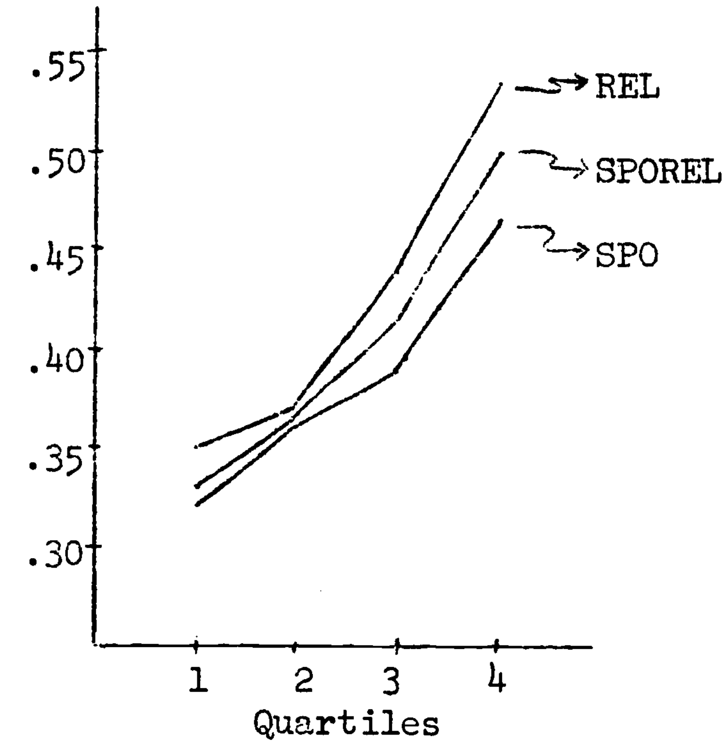


Figure 2

Profiles of Scoring Methods by Quartiles for the Significant (.05) Interaction in the Combination of Loyola Problem 35B and Seventh Amthauer Subtest

Here it can be noticed that there is a difference between the SPO and REL measures of 35B for the first quartile established on the basis of subtest seven. This difference all but disappears for the second quartile, but appears again at a greater magnitude for the third and an even greater magnitude for the fourth quartile. It is helpful to understand what is occurring here by studying particularly two types of protocols and their frequency of occurrence in each of the four quartiles. It is necessary for the sake of clarity to make two definitions with respect to these types of protocols. A protocol that contains relevant questions none of which are asked in the proper order will be called an "order-irrelevant" protocol. A protocol without any relevant questions whatsoever will be termed a "completely irrelevant" protocol. An "order-irrelevant" protocol will receive a zero score according to the SPO method but will receive some value in the REL method since some relevant questions are to be found there. A "completely irrelevant" protocol will receive no value from either the SPO or the REL method. Inspection of representative instances of non-significant interactions indicates that the ratio of "order-irrelevant" to "completely irrelevant" protocols remains quite constant for all quartiles in a given analysis of variance application, though the ratio itself is free to vary from application to application. However, in the instance involving significant interactions, this ratio does not remain constant from quartile to quartile. This gives rise to changing differences in the measures of the quartiles' performances on a particular Loyola problem according to the two methods of scoring. For example, in Figure 2, taking the two quartiles where these differences can be expected to be emphasized, viz. the second and fourth quartiles, the second quartile has a ratio of 1.15 of "order-irrelevant" to "completely irrelevant" protocols whereas the fourth has a ratio of 3.33. It can be noted further that when this ratio approaches 1.00, the two scores from the SPO and REL approach identity. It further remains to say why these changes in ratios for the quartiles within a given analysis of variance application occur where they do. Since neither one subtest nor one problem has been systematically affected in this respect (i.e. significant interactions in all cells of a row or column in Table 3), efforts at producing anything but a rather tenuous interpretation have proven fruitless.

There were occasional minor violations of homogeneity assumptions with regard to the pooling procedures for the error terms using the "F maximum" test. However, Box (1) has shown the F tests concerned to be robust with respect to such eventualities. In addition there is no systematic difference in interpretation between cases where minor violations occur and where the homogeneity assumptions are strictly met.

Besides the above assumptions, the usual F tests in designs of this type require assumptions with respect to the equality and symmetry of covariance matrices. A conservative test is available which renders unnecessary the latter assumptions. The results presented in the tables follow the usual tests. Applying the conservative tests introduced the following results: 1.) no change in decisions or levels for Table 2 (Table 1 is not involved in this whole issue), 2.) in Table 3 all decisions at the .05 level would be reduced to statistical insignificance excepting the interaction for problem 35B in the fourth subtest, which remains unchanged, 3.) in Table 3 all decisions at the .01 level are reduced to the .05 level excepting problem 31A in the ninth subtest, which also remains unchanged. Therefore, further doubt is attached to the importance of interpreting the significant interactions since only four remain significant under the conservative test.

In summary, then, using as a criterion for establishing quartiles each of the nine Amthauer subtests, performance on the seven Loyola problems was found to distinguish effectively these quartiles. Moreover, whether Loyola performance was scored according to SPO, REL, or SPOREL, offered no advantage in all but a few cases. Whereas there were always significant differences between the methods, these differences were in all but very few cases constant as indicated by the parallelism of the profiles. On these bases together with previous experience and information, the SPO method was selected for use in later critical analyses. An analysis of the means for the quartiles in the various applications indicated that not every pair of quartiles could be expected to differ significantly and in the predicted direction. The results indicate that such a conclusion should be limited to median divisions.

The remainder of phase one, corresponding to the first objective, dealt with the ability of the Loyola problems and their methods of evaluation in distinguishing the levels of education. For this a two factor design with repeated measures on the second factor was applied seven times (once for each Loyola problem). The first factor (A) corresponded to the three levels of education and factor B, to the three methods of scoring. The results were highly consistent as can be seen in Table 4.

Table 4

Summary of Significance Decisions for Main Effects of Factor A (Levels of Education), for Factor B (Scoring Methods), and Interactions AB for the Seven Loyola Problems

Loyola Problems

Effects	31A	31B	31D	42	35A	35B	35D
A	.01	.01	.01	.01	.01	.01	.01
B	.01	.01	.01	.01	.01	.01	.01
AB	NS	NS	NS	NS	NS	NS	NS

For every problem the three levels of education (Gymnasium, Sekundarschule, and Realschule) were distinguished at the .01 level. The three scoring methods were again differentiated at the .01 level for each problem, but the lack of a single significant interaction indicates that the scoring methods generated parallel profiles and did not differ among themselves in the way in which they were sensitive to performance of the three levels of education.

An inspection of the means indicates that performance was in the expected direction (Gymnasium > Sekundarshule > Realschule) with the exception of problems 35B and 35D. In both instances the Sekundarschule had a higher mean than the Gymnasium; both, however, higher than the Realschule. These occurrences seem related to variables other than problem solving ability. It has been suggested by researchers native to

Switzerland, and more familiar with characteristics of these levels, that a Gymnasium student is less likely than a Sekundarschule student to attempt a problem that he feels is beyond his capability and thus risk a foolish reply. Since guessing can be awarded a value by all of the three methods, this was not to their advantage. The experimental evidence related to this possibility would be a comparison of the numbers of unattempted protocols for each group in the two problems. This evidence is found to support such a theory in that in problem 35B only 5% of the Sekundarschule students did not attempt the problem as compared to 19% for Gymnasium. In problem 35D the two percentages are 16% and 39% respectively. This would definitely influence the means in the direction observed and suggests the plausibility of the above interpretation.

Phase two dealt with objective two which studied the ability of the Amthauer intelligence test to differentiate levels of education. This was accomplished by nine single factor designs, one for each subtest, where the levels of education composed the factor. From Table 5, it can be seen that the only subtest not distinguishing the levels of education was the eighth.

Table 5

Summary of Significance Decisions
for Effects of Treatments (Levels of Education)
for Each Amthauer Subtest

Amthauer Subtests

	1st	2nd	3rd	4th	5th	6th	7th	8th	9th
Treat.	.01	.01	.01	.01	.01	.01	.01	NS	.01

It will be recalled that this is the Cube Problems subtest and purports to measure spatial representation and analytic thinking. If, indeed, these attributes are measured by this test, then these results indicate that they are not good differentiators for level of academic achievement in the Zürich school system.

Phase three treats the issue of performance on the Piaget problems as a criterion for level of academic achievement. For this analysis each Piaget experiment is treated separately and the chi square analysis is employed to study association between level of education and stage performance in a given Piaget experiment. Because of the requirements for a meaningful chi square test (23) it was not always possible to include all three major stage levels in a particular analysis. The same observation is also to be applied to the analyses involving sub-stage levels. This is not so disappointing as it would seem since, according to Piaget, the number of such cases as were omitted in the analyses should be quite insignificant within the age range studied.

In the first problem the number of protocols falling into major stages II and III for the three levels of education were considered. These figures are presented in Table 6 accompanied by the chi square value and level of significance.

Table 6

Chi-Square Analysis of Educational Levels (Realschule, Sekundarschule, Gymnasium) by Major Stages of Combinations Experiment

	II	III	
R	45	9	54
S	39	20	59
G	31	28	59
	115	57	172

$\chi^2 = 12.18^{**}$

For this same Piaget experiment (Combinations), the distribution of protocols for the three levels of education into substages IIA, IIB, IIIA, and IIIB, was evaluated under the hypothesis of no association with the corresponding results presented in Table 7.

Table 7

Chi-Square Analysis of Educational Levels by Substages of Combinations Experiment

	IIA	IIB	IIIA	IIIB	
R	26	19	5	4	54
S	13	26	18	2	59
G	14	17	19	9	59
	53	62	42	15	172

$\chi^2 = 22.94^{**}$

Both of these findings have a probability, $p < .01$, indicating that levels of education are distinguishable by means of the first Piaget experiment whether the analysis is by the major or the sub stages involved.

These findings indicate definite differences between the Realschule and Gymnasium levels but leave the question as to differences between Realschule-Sekundarschule and Sekundarschule-Gymnasium open. For this purpose, where possible, more detailed analyses involving these comparisons were initiated.

Table 8

Chi-Square Analysis of Realschule-Sekundarschule and Sekundarschule-Gymnasium Comparisons for Major and Sub-stages of Combinations Experiment

	II	III	
R	45	9	54
S	39	20	59
	84	29	113

$\chi^2 = 4.39$*

	IIA	IIB	IIIA	IIIB	
R	26	19	5	4	54
S	13	26	18	2	59
	39	45	23	6	113

$\chi^2 = 13.23$**

	II	III	
S	39	20	59
G	31	28	59
	70	48	118

χ^2 - NS

	IIA	IIB	IIIA	IIIB	
S	13	26	18	2	59
G	14	17	15	9	59
	27	43	37	11	118

χ^2 - NS

In the case of the first Piaget experiment Table 8 indicates that differences exist between the Realschule and Sekundarschule but not between the Sekundarschule and Gymnasium. This finding holds whether the analysis is by the major or the substages employed.

The next Piaget experiment was the Probability problem. This problem found a sufficient number of observations of a stage I classification to permit the inclusion of that stage in the analysis. This finding in itself does not seem to agree with what Piaget would predict. At any rate, the findings of this research as seen in Table 9 for the major stages and Table 10 for the substages that were possible to analyze, shows this experiment also to be effective in differentiating levels of education. This holds then when using the three major stages or substages IIA, IIB, and IIIA.

Table 9

Chi-Square Analysis of Educational Levels by Major Stages of Probability Experiment

	I	II	III	
R	6	53	2	61
S	8	53	4	65
G	3	39	17	59
	17	145	23	118

$\chi^2 = 22.65$**

Table 10

Chi-Squares Analysis of Educational Levels by Substages of Probability Experiment

	IIA	IIB	IIIA	
R	21	32	2	55
S	16	37	4	57
G	9	30	11	50
	46	99	17	62

$\chi^2 = 13.72$**

Trying to specify in more detail what pairs of levels could be discriminated resulted in the analyses presented in Table 11.

Table 11

Chi-Square Analysis of Realschule-Sekundarschule and Sekundarschule-Gymnasium Comparisons for Major and Sub-stages of Probability Experiment

	I	II	
R	6	53	59
S	8	53	61
	14	106	120

χ^2 - NS

	IIA	IIB	
R	21	32	53
S	16	37	53
	37	69	106

χ^2 - NS

	I	II	III	
S	8	53	4	65
G	3	39	17	59
	11	92	21	124

$\chi^2 = 12.88$**

	IIA	IIB	IIIA	
S	16	37	4	57
G	9	30	11	50
	25	67	15	107

χ^2 - NS

Here it can be seen with reference to the major stages that only the Sekundarschule and Gymnasium exhibit differences. In the substage analysis for the Realschule-Sekundarschule comparison it was necessary to delete substage III A because of too few entries. The resulting analysis only indicates that there is no significant association between membership in

Realschule or Sekundarschule and performance in substage IIA or IIB. In the substage Sekundarschule-Gymnasium comparison, no differences of a significant nature were noted. It must be noted here that in order to perform the substage analysis, stage I performance had to be omitted as well as substage IIIB. In this instance this seems to account for the negative findings with respect to the Sekundarschule-Gymnasium comparison.

The Balance experiment results for the three levels in terms of major and substage analyses are described in Tables 12 and 13.

Table 12

Chi-Square Analysis of Educational Levels by Major Stages of Balance Experiment

	II	III	
R	56	3	59
S	62	3	65
G	49	10	59
	167	16	183

$\chi^2 = 7.35$*

Table 13

Chi-Square Analysis of Educational Levels by Substages of Balance Experiment

	IIA	IIB	IIIA	
R	21	35	3	59
S	9	53	3	65
G	11	38	10	59
	41	126	16	183

$\chi^2 = 19.84$**

Thus major stages II and III discriminate levels of education at $p < .05$, and substages IIA, IIB, and IIIA, with a probability, $p < .01$. The level by level comparisons are described in Table 14.

Table 14

Chi-Square Analysis of Realschule-Sekundarschule and Sekundarschule-Gymnasium Comparisons for Major and Sub-Stages of Balance Experiment

	II	III	
R	56	3	59
S	62	3	65
	118	6	124

Fisher's - N.S.

	IIA	IIB	
R	21	35	56
S	9	53	62
	30	88	118

$\chi^2 = 8.19$**

	II	III	
S	62	3	65
G	49	10	59
	1111	13	124

$\chi^2 = 5.03$*

	IIA	IIB	IIIA	
S	9	53	3	65
G	11	38	10	59
	20	91	13	124

$\chi^2 = 6.18$*

First, using Fisher's exact probability test, no significant differences are found for the major stage comparison of Realschule and Sekundarschule. The substage comparison involving only IIA and IIB does differentiate these two levels at the .05 level. The comparison of Sekundarschule and Gymnasium using major stages II and III does differentiate at the .05 level, as does the analysis of substages IIA, IIB, and IIIA for the same two levels.

In general then, for all three Piaget experiments significant associations are found between the three levels of education and major stage classifications on the one hand, and substage classifications on the other, where the major and sub-stages involved are those which the requirements of the particular test permit. From these results it is safe to assume that the Realschule would be distinguished from the Gymnasium in every case. To test possible differences between the other two possible comparisons, more detailed analyses were performed. The Combinations experiment was found to distinguish systematically Realschule from Sekundarschule, but not the latter from Gymnasium. This would be consistent with the interpretation that this problem was easier for the Sekundarschule students and that, thus, they performed at a level comparable to the Gymnasium students. The further inference would be that this is not the best experiment of the three in terms of sensitivity to performance among high achievers in this age range. However, it is systematically more sensitive for low achievers and therefore has its merit. The Probability experiment seems to function better at the upper levels of achievement as is noted by the distinction between Sekundarschule and Gymnasium and the absence of such between Realschule and Sekundarschule. Finally, the Balance experiment perhaps is the one with widest application to the level of academic achievement, since in the substage analysis it distinguishes the lower two levels, and in the major and sub-stage analyses it distinguishes the upper two levels.

With these results in mind, attention is now focused on the fourth objective and the relationship between the major stage classifications and performance on the various Loyola problems. This phase involves three (one for each Piaget experiment) three-factor analyses of variance with repeated measures on the last two factors. The last two factors result from the two ways of classifying the Loyola problems employed, viz. according to intrinsic and extrinsic difficulty. The first factor (A) has three levels, then, corresponding to the three major stages. The second factor (B) is that of intrinsic difficulty and has two levels, 31 and 35. Factor C is the factor of extrinsic difficulty, having three levels A, B, and D, corresponding to the three languages or modes of presentation. Loyola problem 42, which does not fit into the above classification for Loyola problems, will be analyzed separately by means of three single factor applications.

First a general picture of the results for all three Piaget experiments will be presented and then a detailed analysis by Piaget experiment will be made when indicated.

Table 15

Summary of the Significance Decisions for All Effects (A = Piaget Stages, B = Structures, C = Languages) for Each Piaget Experiment

Effects	Piaget Experiments: Comb.	Prob.	Bal.
A	.01	NS	.01
B	NS	NS	NS
AB	NS	NS	NS
C	.01	.01	.01
AC	.05	NS	NS
BC	.05	.05	.05
ABC	NS	NS	NS

Table 15 is a summary of the statistical decisions for the main and interaction effects for all three experiments. From this table it can be observed that the results for the main effects of A indicate a relationship between Loyola problems and Piaget experiments for the Combinations and Balance experiments. The results suggest that these two experiments could be used to establish stage classifications which would be effective,as well, in differentiating performance on the Loyola problems. Here it must be carefully observed that this observation refers to stages in general and to Loyola problems in general. To specify this further either in terms of individual stages or Loyola problems, one must consider other main and interaction effects.

Therefore noting the main effects of B (structures or levels of difficulty) and the main interaction effects AB, it is possible to state that for both levels (31 and 35) of intrinsic difficulty represented in this analysis, no differentiation is possible for the three groups together in any of the experiments. The non-significant decisions with respect to interaction effects AB make possible the extension of this general conclusion to each individual level of A or to each stage therefore. This is possible because the AB results imply that the individual profiles for each stage, when related to levels of B, are parallel and thus react in the same way to the different structures. As an example of such a situation Figure 3 presents the profiles in the AB interaction for the Combinations experiment.

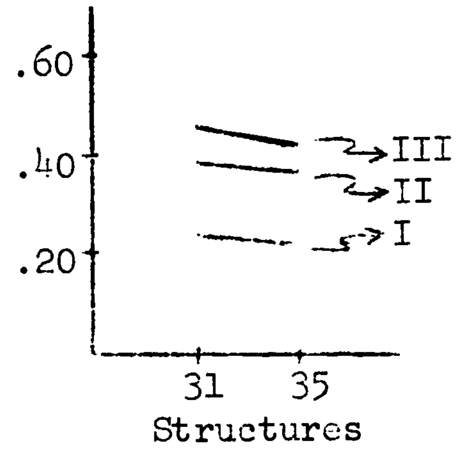


Figure 3

Profiles of the Stages by Structures
Non-significant Interaction for the Combinations Experiment

In this figure one can observe that the reactions are the same for each profile (stage) and that the differences between levels of intrinsic difficulty (b_1 and b_2) are very small, in fact, non-significant.

However, the Probability experiment does not show effectiveness in differentiating performance on Loyola problems according to stages. And similar to the Combinations and Balance experiments no differences are found between levels of intrinsic difficulty (B) where the stages are equally ineffective (AB) in discriminating performance on Loyola problems.

In terms of the three types of languages employed the results of the main effects of factor C are pertinent. The main effects of C are significant at $p < .01$. This finding indicates overall differences between the three languages for each Piaget experiment. These differences between languages or levels of extrinsic difficulty can be said to be of the same type for each stage in the Probability and Balance experiments due to the non-significant AC interactions in both. However, the AC interaction is significant in the Combinations experiment and its implications will be treated below.

With regard to structures, the various languages seem to have differing relationships as is evident from the significant BC interactions in each Piaget experiment. These relationships also will be discussed below. Finally, Table 15 reports that there are no significant interactions of the ABC type indicating that there are no special relationships involving stages, intrinsic difficulty, and extrinsic difficulty simultaneously.

In the Combinations experiment it has been previously noted that there exists a significant AC interaction. This finding implies the necessity of an analysis of the simple effects of A. In order to describe this in more detail it is helpful to consider Figure 4.

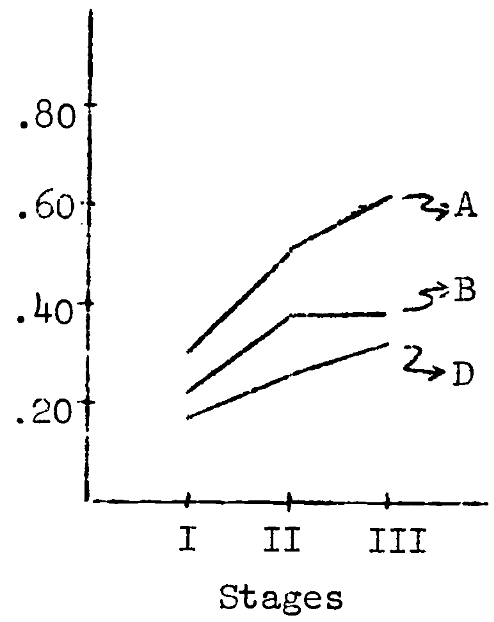
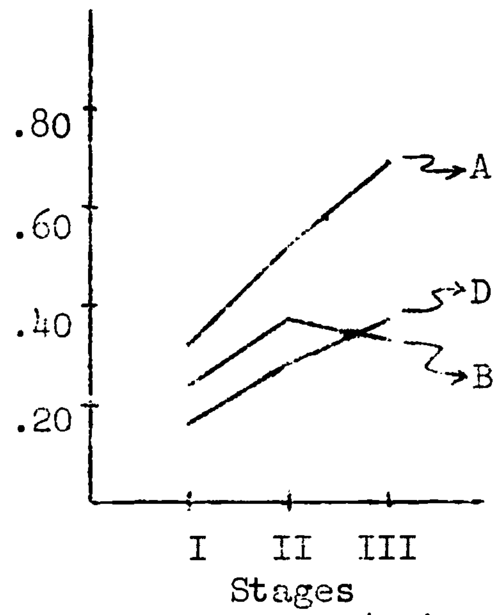


Figure 4

Profiles of the Stages by Languages Significant (.05) Interaction for the Combinations Experiment

This figure presents the profiles corresponding to languages and their relationships and stages (abscissa). Or to state it differently, Figure 4 presents the simple main effects of factor A for the three levels of factor C. The plot shows that performances on problems in the concrete language (language A - first level of factor C) receives the highest values in each of the stages. Language B (abstract-concrete) type problems yield the next best performance, and then finally language C (abstract-abstract). This is as would be predicted on the basis of previous experience with problems representing these languages and also according to the theoretical bases developed. As was said before, the overall main effects of A are significant, but an analysis of the simple main effects of A for the various levels of C indicates that the overall effect is primarily due to the influence of the performance on problems of the concrete language. That is, an analysis of the simple effects shows that the three stages of the Combinations experiment are distinguishable in terms of Loyola performance only for the concrete problems which have an F=12.4 which is significant beyond the .01 level. The profiles for language B and language D are non-significant.

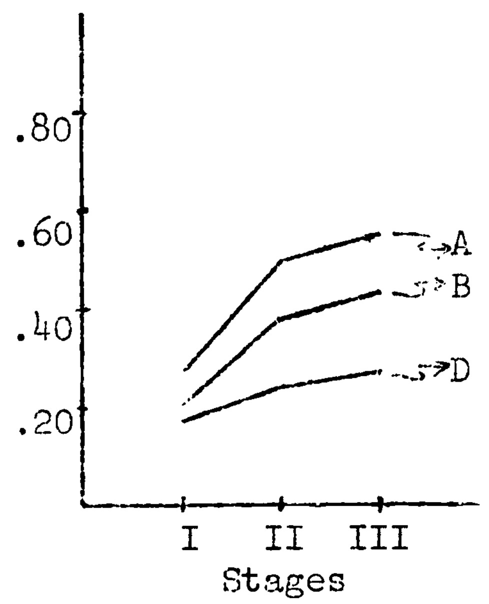
Thus far the analysis has averaged across structures when studying the relationship between stages and languages. If the simple interaction effects AC for level b_1 and AC for level b_2 are plotted (see Figures 5 and 6 respectively), one observes two different sets of profiles.



AC at b_1 (31)

Figure 5

Profiles of Stages by Languages Simple Interaction Effects for Structure 31 in the Combinations Experiment



AC at b_2 (35)

Figure 6

Profiles of Stages by Languages Simple Interaction Effects for Structure 35 in the Combinations Experiment

The obvious difference is that of language B and its relationship to stages for the two structures. That is, the difference being discussed is between Loyola problems 31B and 35B. Pinpointing the "black sheep" a little further indicates that 31B exhibits the most surprising profile. From its profile (B in Figure 5), it can be seen that the stage III group performs only as well (in fact the mean is lower) as the stage II group. Also, whereas the simple main effects corresponding to profiles A and D are significant (A has $F = 13.29$, $p < .01$; D has $F = 4.14$, $p < .05$), the three stage groups are not distinguished by problem 31B. Its counterpart in the 35 structure, 35B, does distinguish stage groups and in the expected direction (Figure 6, profile B), with an $F = 3.71$, $p. < .05$. Loyola problem 35A (profile A), also distinguishes stages ($F = 6.14$, $p. < .01$), but problem 35D does not. Thus clarification is needed for the profiles of problems 31B and 35D. The latter seems to be explained rather easily in that it was a quite difficult and complex problem for the entire sample, and it is not too unexpected that the stages are statistically indistinguishable when performance in general is at the lower limit.

Problem 31B cannot be dismissed so readily. Several considerations are pertinent. First, this is the most conspicuously different of all the profiles under study. Second, the profile of problem 35B, its counterpart in language but with a more complex structure, is quite different from 31B's but more similar to the other profiles. This seems to indicate that perhaps the crucial variable is not the language, but something else. Third, this instance is peculiar to the Combinations experiment as can be concluded from the absence of significant AC interactions in the other two experiments. Therefore the solution must be sought in circumstances peculiar to the Combinations experiment considered simultaneously with the presentation of problem 31B.

The present authors are of the opinion that the effect noted in profile B of Figure 5 is a sequence effect noticeable because of the level of difficulty of the Combinations experiment. The latter is the easiest of the three as can be seen from the number of subjects falling into the stage three classification. Fifty-seven subjects are thus classified for this experiment, as compared to only 23 for the Probability experiment and 16 for the Balance experiment. Keeping this in mind, but at the same time recognizing that problem 31B is the first appearance of an abstract problem of any kind, a solution is suggested. It seems probable that because of the relative simplicity of the Combinations experiment, subjects who in the other experiments were distributed in the lower two stages can be found in this experiment in stage III. If this is the case, it is this type of subject who could be expected to have the most negative experience with a first encounter with an abstract problem.

This situation would have the effect of lowering the mean performance for the stage III group, so that, in the end, little difference remained between stage II and stage III performance on this problem. It is suggested that these stage III subjects, though, who it might be said just qualified for stage III, were able to benefit by the training they received in this problem more than those from the lower stages. The learning involved was such that the performance of the stage III group as a whole improved more, relative to the other two groups, when succeeding abstract-type problems occurred, as with problems 31D and 35B. Therefore, differences between stages in these two abstract problems could be observed once again.

In the same Combinations experiment, the BC interaction was also found to be significant. As can be seen from a plot of the profiles, Figure 7, this results primarily because of a learning effect similar to that noted above.

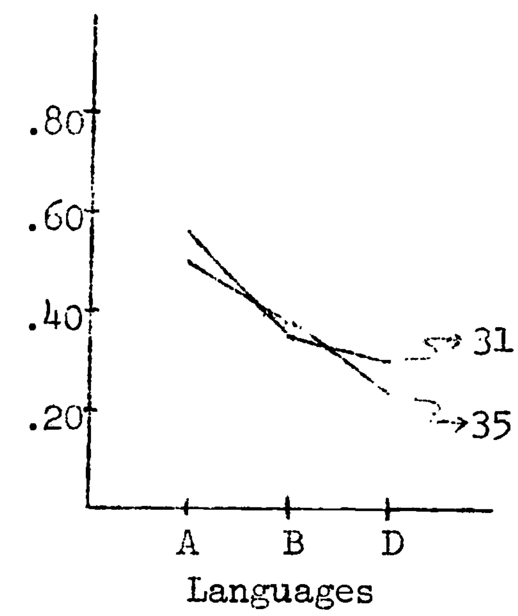


Figure 7

Profiles of Structures by Languages Significant (.05) Interaction for the Combinations Experiment

That is, the profiles would be parallel except for an intersection at the language B point. This indicates better performance on problem 35B than on problem 31B. Therefore, the first encounter with an abstract problem resulted in such a depressed performance for that problem (31B), that the learning involved was sufficient to provide for a better performance on a more complex problem met later (35B). The implications here are that this occurred for the three groups as a whole, but it has been shown previously, in the discussion of the AC interaction, that this effect is most marked with the stage III group. Finally, it should be noted that both profiles in Figure 7 indicate significant differences among types of language, i.e. the simple main effects of C at level b_1 (31) have an F=45.50, p <.01, and the simple main effects of C at level b_2 (35) have an F=38.12, p <.01. This indicates that languages are differentiated for both structures.

Concerning the second Piaget experiment, it remains to describe the implications of the significant BC interaction. But since this interaction does not involve the stages or levels of factor A, the means, sums of squares, etc., involved in its evaluation are the same as for the Combinations experiment. In fact, the relevant data will be identical for the Balance experiment. Therefore, what has been said previously with respect to the Combinations experiment in terms of its significant BC interaction must be equally applicable for the significant BC interactions in the Probability and Balance experiments. In fact, Figure 7 can be used equally well to describe the BC interactions for these two experiments. The findings with regard to the simple main effects of C at levels b_1 and b_2 have equal application.

The above results were based on usual tests of significance for the F ratios involved. This assumes the equality and symmetry of the covariance matrices involved. If one has reason to doubt that these assumptions are valid, then a conservative test is available which does not require those assumptions. While the authors thought the usual test valid under present conditions, the conservative test was conducted for possible comparison of results by the reader. The findings under the conservative test do not change any of the results with respect to main effects of factors A or C. However, the interactions of all orders would no longer be significant. Thus the major findings stating the effectiveness of the stage classifications of the Combinations and Balance experiments in differentiating performance on the Loyola problems would remain. Also, the differences seen between languages would be sustained. However, the necessity of the interpretations of the learning effect in both the AC and BC interactions would be obviated. Yet, from the previous literature with the Loyola problems, a language by structure interaction with the sequential learning effect is expected, confirming the convictions of the authors in the validity of the usual test and the interactions discovered.

Under the fourth objective there yet remains the discussion of the relationship between performance on Loyola problem 42 and major stage classifications for the three Piaget experiments. The analysis was approached by means of a single factor design with the three levels of the factor corresponding to the three major stages in a Piaget experiment. The criterion scores were those calculated for Loyola problem 42 by the SPO method. The design was repeated three times. The results of the significance decisions for each Piaget experiment are found in Table 16.

Table 16

Summary of Significance Decisions for Effects of Treatments (Major Stages) for Each Piaget Experiment Based on Loyola Problem 42

	Comb.	Prob.	Bal.
Loyola #42	NS	NS	NS

From this table it is immediately apparent that Loyola problem 42 does not provide an effective means of differentiating stage performance on any Piaget experiment. It will be recalled that this was a Loyola problem of the geometric type and these findings, then, have definite implications for future use of such problems when a relationship with Piaget performance is the subject of study.

The fifth objective treated the ability of the various Amthauer subtests in distinguishing the major stages of each Piaget experiment. This was accomplished by a single factor design identical to that used for Loyola problem 42, with the sole exception that the criterion scores were the performances on the various Amthauer subtests. There were, therefore, three applications of the design for each subtest (one for each Piaget experiment), yielding a total of 27 analyses. Table 17 reports the significance decisions for the 27 applications.

Table 17

Summary of Significance Decisions for Effects of Treatments (Major Stages) for All Combinations of Piaget Experiments and Amthauer Subtests

	Amthauer Subtests								
	1	2	3	4	5	6	7	8	9
Comb.	NS	.05	.01	.01	.01	.01	.01	NS	NS
Prob.	.01	.01	.01	.01	.01	NS	NS	NS	NS
Bal.	.01	NS	.05	NS	.01	.01	NS	.05	NS

Critical values 3.04*
4.71**

In general, with respect to the Piaget content areas under study, the Analogies (3rd), Arithmetic Problems (5th), and Memory (9th) subtests show systematic results. That is, Arithmetic Problems and Analogies seem to be most related to stage classification, and Memory, completely unrelated. The latter result is quite in accord with expectations based on the definition of the instruments involved. Arithmetic Problems involve a very similar type of item to the experimental situation encountered in the Piaget tasks, in that both present concrete problem solving type of situations and both imply arithmetic and calculations. Using the description of the attributes tapped by the Analogies subtest one finds a rather general type of cognitive ability, i.e. ability for combining and flexibility in thinking, realization of relations, compulsiveness or precision in thought. It is difficult to imagine any purposeful cognitive activity which does not reflect one or several of these attributes such that it is not surprising that they are involved in performance on the Piaget experiments.

Aside from these systematic findings, one can observe only partial relationships between subtests and Piaget experiments. Therefore, each remaining subtest will be inspected and, if possible, suggestions offered to explain the findings. Subtest 1 (Sentence Completion) successfully differentiates the stage groups for the Probability (2) and Balance (3) experiments, but not for the Combinations task (1). The first subtest purports to measure common sense, sense of reality, and thinking in a concrete practical way. The results seem reasonable then, since the applications of the elements involved in experiments 2 and 3 to everyday life seem more clear than the corresponding elements of the Combinations experiment.

Amthauer subtest two (Word Choice) attempts to provide a norm for facility of common concepts. Though a clear interpretation is admittedly difficult, there does seem to be a plausible explanation of the fact that this subtest fails to distinguish stages for the Balance experiment. From the criteria for evaluating stage performance it can be seen that the principal difference between stages II and III was the ability of the subject to quantify the solution. This does not seem to involve differences in the facility with common concepts; hence, the criterion of common concepts would fail to distinguish the stages. Corroborative evidence seems to be available by significant findings for the Balance experiment in subtests 5 and 6 which purport to treat more specifically mathematical concepts.

The Communalities subtest (4) measures ability for abstraction, concept construction, and verbal expression. This subtest successfully differentiates stages for the

Combinations and Probability experiments but not for the Balance. Considering the type of activities involved in the former two but not in the latter indicates the interpretation. Since the Balance problem was the only experiment in which quite direct feedback of progress was possible as to the effects of physical operations, it seems that this experiment may not have required the degree of abstractive ability required in the first two and thus the Communalities test would not effectively discriminate stages in this Balance experiment. This interpretation makes the subtest more a measure of pure abstractive ability rather than a measure of abstraction as aided by the manifestation of physical events.

The sixth Amthauer subtest (Number Series) fails to differentiate stages only for the Probability experiment. This is somewhat surprising in that inductive thinking with numbers and theoretically oriented arithmetic thinking would seem to be quite basic to a notion of probability. The means of the stages for this subtest were inspected and the first two groups revealed no practical difference. This is not unexpected in that several experimenters suspected that the performances of some stage I classified subjects did not really represent their facility with notions of probability as much as problems involving communication. If this is true, then one can understand differentiation by subtests where verbal skills were measured, as well as the lack of distinction for those subtests where such skills are not the crucial variable, such as the present instance.

The Figure Choice subtest (7) clearly involves representational imagination if one analyzes the type of items composing the test. In the opinion of the authors this quality of the test is of primary importance. Furthermore, this aspect seems to be quite important in the Combinations experiment which alone has its stage groups differentiated by this subtest. In analyzing the activity involved in specifying the pairs for this experiment the authors feel the subject could be expected to rely quite heavily on his imagination to furnish a plan according to which he could specify the different pairs. This imaginative activity cannot be seen so clearly to relate to the activities involved in the other two experiments, as the results indicate.

The last subtest to be considered is the Cube Problems (8). In Table 17 it is noted that performance on this test is related only to performance on the Balance experiment. Recalling an earlier finding involving this subtest and its inability to distinguish levels of education may help to formulate an interpretation. That is, the test does not seem to measure performance closely related to academic achievement. Nor does this test correlate highly with any of the other Amthauer subtests. The highest is .37 with the seventh subtest while the values of the other correlation coefficients are equal to or less than .20. On the basis of evidence such as this, the authors suggest that the subtest may be evaluating characteristics closely dependent upon common experience and the ability for careful observation. Good performance on both of the instruments seems to be closely related to these two attributes when the experimental situation of each instrument is considered. That is, common experience can facilitate performance in the Cube Problems as well as in the Balance experiment. And much can be gained in both by careful observation. The argument here is not that these qualities are uninvolved in the other subtests and other Piaget experiments, but that they are not involved to the same extent.

In summary, the findings indicate that general conclusions relevant to the Piaget content studied must be limited to the subtests Analogies, Arithmetic Problems, and Memory. For the rest it is necessary to consider the special characteristics involved in the particular subtest and Piaget experiment being investigated.

Objectives six, seven, and eight involved the identification of the factor structures for the combined Loyola and Amthauer batteries and the invariance of these structures under changing characteristics of the samples involved.

The first step suggested was the identification of the factor structure for the entire sample of subjects including those for whom no data from Piaget experiments was available. The correlations were calculated and the principal factor solution obtained using the simultaneous Jacobi solution.

The results obtained precluded any further work in this direction. Several considerations led to this decision. Six of the eigen values obtained were negative and this cast some doubt on the validity of the factor analytic application. Until this question, related to the Gramian properties of the correlation matrix, is resolved, further pursuit of the factor analytic phase is not indicated. However, the prospect of meaningful results in this phase is by no means ruled out. Given facilities and time not available under the terms of this project, the authors are confident that a satisfactory solution to this phase of the research can be achieved. The results obtained within the limits of the present research are presented at the end of Appendix III.

IV. Conclusions and Recommendations

From the findings of the analyses in the first phase (associated with the first objective), it was not possible to select a preferred method of evaluating the problem solving processes of the Loyola problems when the criterion for such a selection was the ability of the Loyola problems, so scored, to distinguish quartile groups established by each of the Amthauer subtests. Though, without exception, the scoring methods were seen to be yielding different measures, the differences thus obtained were almost universally constant. These constant differences, observable from the absence of any systematic interaction between methods and quartiles, imply very high correlations between the methods. Therefore, while theoretically the methods were thought to measure different aspects of the process (relevancy and order), empirically these aspects were found to exhibit a very high positive relationship. This finding is valid at least when performance on the Loyola problems is related to a sampling of intelligence variables such as found in the Amthauer test. Furthermore, this finding can be extended to the use of Loyola problems in distinguishing levels of academic achievement since in that application no single interaction was found between levels and scoring methods. Thus, in the Swiss sample under study no meaningful differences are found among the SPO, REL, and SPOREL methods of evaluating Loyola problem solving performance when this performance is related to intelligence or achievement variables. This finding seems to indicate that whether the process of a Loyola problem is viewed primarily from the aspect of its order or exclusively in terms of its relevancy, essentially the same picture will be retrieved at least when Loyola performance is related to intelligence or scholastic achievement.

Because empirical evidence was lacking to make a preferential decision, the SPO was chosen on the basis of considerations related to information and experience.

Of additional interest from the foregoing inquireis, it is possible to state that all Loyola problems were effective in distinguishing quartiles established by the six verbal and quantitative Amthauer subtests and also levels of academic achievement as represented by the Gymnasium, Sekundarschule, and Realschule. Quartiles of the three Amthauer subtests related to space and memory can with equal effectiveness be differentiated by Loyola problems 31A, 35A, and 35B but not so systematically by the other Loyola problems. Specifically, Loyola problem 42, the figure problem, proves to be singularly ineffective. These findings suggest very strongly the usefulness of the Loyola concrete problems, in particular, as selection or evaluation devices where the pertinent variables are academic achievement or intellectual capacity. Thus the results not only echo the implications for these instruments based on American samples, but also indicate that these instruments may possess culture-free aspects which make them readily adaptable for use in many countries and for cross-cultural studies, at least within the Western sphere of influence.

The next phase indicated that all subtests of the Amthauer were effective in discriminating levels of achievement with the exception of the Cube Problems subtest. This finding is important for this research in that it provides auxiliary information concerning the levels of education which were differentiated by the Loyola problems as well. Corroborative evidence then is provided for the finding relating the ability of the Loyola problems to distinguish quartiles on the Amthauer subtests. This information should be useful to the Swiss users of the test who employ it in selection and/or evaluation applications.

The next set of findings indicated that levels of education could be successfully distinguished by major stage classifications in each Piaget experiment. Therefore, some of the traits that distinguish levels of education must be found in the Piaget experiments as well. When the same major stages are divided into substages and these are found suitable for comparison, similar effectiveness is observed. This not only suggests a relationship between Piaget performance and academic achievement, but to a certain extent confirms the criteria which the experimenters used to evaluate Piaget experiments. The criteria for the substages receive the same type of support since the results using them agree with the major stage findings. Further, indirect evidence as to the difficulty of the problems was offered by the paired comparisons of the levels of education. This evidence coincided with the experimenters' information and opinion, and indicated increasing difficulty according to the order of presentation.

Since these latter findings with levels of academic achievement and those of Loyola problems and Amthauer subtests with the same variable presented similar results, the expectations for relationships between Piaget performance and Loyola problems, on the one hand, and Amthauer subtests, on the other, were considerably enhanced. That is, all three sets of instruments seem to involve variables predictive of academic achievement. The question of the degree of the relationships was better indicated by the following phase.

In this phase, the direct comparison of Loyola and Piaget performance indicated that Loyola problems of the 31 and 35 series could effectively distinguish stage groups for the Combinations and Balance experiments. The results further specify that Loyola problems of differing extrinsic difficulty do not distinguish stages equally well in every case. For instance, in the Combinations experiment, the concrete language is superior to the other two in this capacity. Yet, for the Balance experiment, all languages seem equally effective. All of the 31 and 35 Loyola problems were equally ineffective with respect to the Probability experiment. Loyola problem 42 was ineffective for all experiments studied.

In general these findings point to the necessity of empirical verification of apparent similarities between the Loyola and Piaget models. Also, it must be concluded that related evidence can be quite deceiving.

Concerning the latter, it was noted that Loyola problem 42 successfully differentiated levels of education as did the three Piaget experiments. Yet there appeared no differences between the three stages in their Loyola problem 42 performance for any of the three experiments. Therefore, the characteristics that each is sensitive to in levels of education must be different for each.

The necessity of empirical verification derives from the unsystematic nature of the findings. Stages of the Probability experiment were not distinguished by any Loyola problem; stages of the Combinations experiment, distinguished only by the concrete problems; stages of the Balance experiment, distinguished in the same way, by all the Loyola problems excepting 42.

Thus, if a relationship is to be found, it is most likely to be found with a concrete language problem as opposed to a geometric type problem.

Further, it is somewhat astonishing that, in general, levels of intrinsic difficulty were not distinguishable. This could conceivable be explained by the presence of a learning effect in that the 31 problems were more difficult than expected because they were presented first, and the 35 problems, easier than expected by virtue of the training on the 31 problems. A leveling effect could have thus occurred obscuring any possible differences. In view of the absence of a difference between structures, the absence of a differential relationship of each structure to the stages of each experiment is not so surprising.

Due to considerations such as the above, it now appears more important than ever not only to control learning effects but, if possible, to eliminate their influencing the results. This might be accomplished by conducting extensive training with the samples on all types of problems, or employing a design permitting the randomized presentation of problems. The authors would hypothesize under such circumstances the appearance of a difference between structures as well as the disappearance of the language and structure interaction observed in this study.

A most important feature of these results is the lack of significant interactions between stages and structures as well as between stages and languages. Granted there was an instance of the latter case, but the obvious interpretation does not attribute its cause to a Piagetian variable but rather to aspects of the experimental presentation. If such interactions had been observable, this would have indicated that the differing levels of extrinsic and/or intrinsic difficulty would be related to Piaget's analysis of intellectual development. This would have provided a precise area of investigation and have indicated how theoretically developed variables from each model interacted. As things now stand, the indications are that the Loyola problems with different structures and different languages relate to the different stages of Piaget performance in the same way. This evidence, obviously, cannot be taken to imply for either model that the aspects of its theory involved are unfounded. It does seem to indicate that these aspects are not similar notions. Again the reader should be cautioned that training effects have apparently served to cloud the issues and only when this problem is satisfactorily resolved, can more definite decisions be taken.

Throughout this discussion, one must not lose sight of the fact that Piaget experiments and Loyola problems can be found which have a common ground for evaluation. It remains for future research to give a clear definition and identification to this common ground. It seems odd, for example, that in the Probability experiment and in the Loyola problems where it appears equally important to isolate, identify, and determine the relationships for important variables, no common ground occurs. The question, of course, is why. One explanation would be that the models are not measuring these cognitive operations and that their common ground is more related to content. This possibility does not seem as plausible as one which postulates the lack of sensitivity of one of the applications of the models to this issue. Since the same Loyola problems do distinguish stages for the other two Piaget experiments, the lack of sensitivity seems better attributed to the present application of the Probability experiment. It did, however, distinguish levels of education, but this might have been, and apparently was, on different bases, since the Loyola problems performed the same function.

The first possibility must not be dismissed lightly, since it cannot, by present evidence, be contra-indicated. In fact, there exists some plausibility for it in the findings that for the Combinations experiment the concrete language problems discriminate the stages the best. (Content, in this usage, implies a concrete expression of the task.) Yet, because for the Balance experiment, all Loyola languages equally distinguish stages, the implication seems to be that a common ground for the two models exists only when the Piaget experiments involve some concrete content. This suggests that the Piaget experiments measure cognative operations only because the latter are related to the manipulation of concrete symbols which in fact the experiments do measure. Regardless, sufficient evidence is not presented here for either opinion with an acceptable degree of certainty.

As a side issue these analyses did confirm for the Swiss sample the differences between levels of extrinsic difficulty. Once again the findings with the Loyola problems on American samples are seen to be capable of extension to a different Western culture.

Finally, the maximum generalization from the study of the effectiveness of the Amthauer subtests to distinguish stages, is that subtests related to verbal and quantitative abilities show the greatest relationship. Taken in its strongest sense, this might support the hypothesis that the Piaget experiments measure primarily the manipulation of symbols from a concrete context. However, this cannot be considered sufficient evidence in itself since the Loyola problems were seen to distinguish quartiles best, for the same subtests.

While involved with the administration of the Piaget experiments, the use of these instruments in an educational setting repeatedly was considered. This question, it seems to the authors, should be considered from two standpoints, the practical and the theoretical.

On a practical basis, the answer would have to be in the negative. Several considerations demand this reply. The technique is more intuitive than objective. The investment in training qualified administrators would be too great. The criteria as available are too nebulous and ambiguous to permit reliable evaluation. The elements of the stimulus presentation do not, without difficulty and, perhaps, undesirable consequences, admit of standardization, In short, the future for the psychometrization of the Piaget experiments does not appear too promising.

From the theoretical view, applications are potentially numerous and rich. This presumes, however, that the correspondence between Piaget's theory and his experiments is established. This, however, has encountered substantial opposition.

In the view of the present authors, the greatest merit of the Piaget experiments for educational purposes is indirect. Perhaps, through comparative research such as this, they may help to enrich approaches more suitable for application to the educational field.

On the whole, the research seems to have generated more questions than it answered. This is seldom a negative evaluation of research especially when it is an initial investigation into an area. The authors feel that the greatest merit of the research is that it has submitted empirical evidence of similarities between the two models and also delineated more specific lines along which future investigations should proceed.

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A N W E I S U N G

Es wurde dir ein kleines Kartenpaket und ein Antwortblatt ausgeteilt. Alle Karten zusammen machen eine Aufgabe aus. Auf der ersten Karte steht das Problem, das zu lösen ist. Lies es jetzt in dem Beispiel!

Auf den restlichen Karten stehen verschiedene Fragen. Lies diese Fragen jetzt durch!

Die Antworten zu diesen Fragen können dir helfen, die Lösung des Problems zu finden.

Die Antwort zu einer bestimmten Frage findest du auf der Rückseite der betreffenden Karte.

Gehe bei der Arbeit in der folgenden Weise vor:

a) Lies das Problem auf der ersten Karte sorgfältig!

b) Lies alle Fragen auf den andern Karten durch.

c) Entscheide dann, welche Frage du zuerst beantwortet haben willst.

d) Schreibe ihre Nummer auf das Antwortblatt neben 1. in der Kolonne der betreffemden Aufgabe. Wenn du Nummer 3 zuerst fragen willst, dann schreibe 3 neben 1.

e) Nachdem du die Nummer der Frage auf das Antwortblatt geschrieben hast, kannst du die Antwort auf der Rückseite der Karte lesen. Drehe jetzt Karte 3 um und lies die Antwort. Du kannst die Seite mit der Antwort aufgedeckt lassen, bis du mit der ganzen Aufgabe fertig bist.

f) Entscheide dann, welche Frage du weiter stellen willst. Nehmen wir an, es sei Frage nummer 1. Schreibe diese Nummer 1 neben 2. in der Kolonne auf dem Antwortblatt.

Arbeite in dieser Weise weiter, bis du denkst, dass du die Lösung zum Problem gefunden hast. Du kannst so viele Fragen stellen, wie du willst. Aber frage nicht mehr, als du wirklich brauchst, um das Problem zu lösen!

Wenn du die Lösung gefunden hast, schreibe sie auf die leere Zeile auf dem Antwortblatt. Strecke dann die Hand auf, damit man dir die nächste Aufgabe bringt.

Das leere Blatt ist Notizpapier.

Du darfst nichts mehr an den Nummern der Fragen ändern, wenn du sie einmal aufgeschrieben hast: also bitte nichts daran korrigieren!

Die Arbeit mit diesen Aufgaben auf den Karten hat gar nichts mit der Schule zu tun; wir brauchen die Resultate für eine psychologische Forschungsarbeit.

INSTRUCTIONS

You have received a small packet of cards and an answer sheet. All of the cards together comprise a problem. On the first card is the statement of the problem which you are to solve. Read it now in the example.

On the remaining cards are various questions. Now read through all these questions.

The answers to these questions can help you to find the solution to the problem.

You can find the answer to a particular question on the reverse side of the corresponding card.

Approach your work in the following manner:

a) Read carefully the problem on the first card.

b) Read through all the questions on the other cards.

c) Decide then, which question you would like to have answered first.

d) Write its number on the answer sheet next to 1. in the column of the appropriate problem. If you wish to ask number 3 first, then write 3 next to 1.

e) After you have written the number of the question on the answer sheet, you can read the answer on the reverse side of the card. Now turn card 3 over and read the answer. You can leave the side with the answer exposed, until you are completely finished with the problem.

f) Decide then which question you would like to ask next. Suppose we decided to select number 1. Write this number 1 next to 2 in the column on the answer sheet.

Continue working in this fashion until you think you have found the solution to the problem. You can ask as many questions as you wish. But do not ask more than you really need to solve the problem.

If you have found the solution, write it on the empty line provided on the answer sheet. Then raise your hand, so that the next problem can be brought to you.

The empty piece of paper is for notes.

You may not change the numbers of the questions once they have been recorded: therefore, please make no corrections.

The work with these problems is in no way connected with your school; the results will be used for psychological research.

Appendix I

Aufgabe 29A (Illustration Problem)

Instructions and Corresponding Questions and Answers

In der Figur sind ein Rechteck, ein Dreieck und ein Kreis übereinander gelagert; so entstehen die Felder A, B, C, D und E. B, C und D sind alles einzelne Felder, obwohl sie auch alle zum Rechteck gehören.

Eines dieser Felder wurde zufällig bestimmt; du sollst herausfinden, welches der Felder ausgewählt wurde.

Fragen	Antworten
1. Ist es das kleinste Feld?	1. Nein
2. Ist es das grösste Feld?	2. Nein
3. Hat es eine gebogene Seite?	3. Nein
4. Hat es zwei oder mehr Seiten?	4. Ja

Solution: Feld B

Appendix I

Problem 29A (Illustration Problem--English Version)

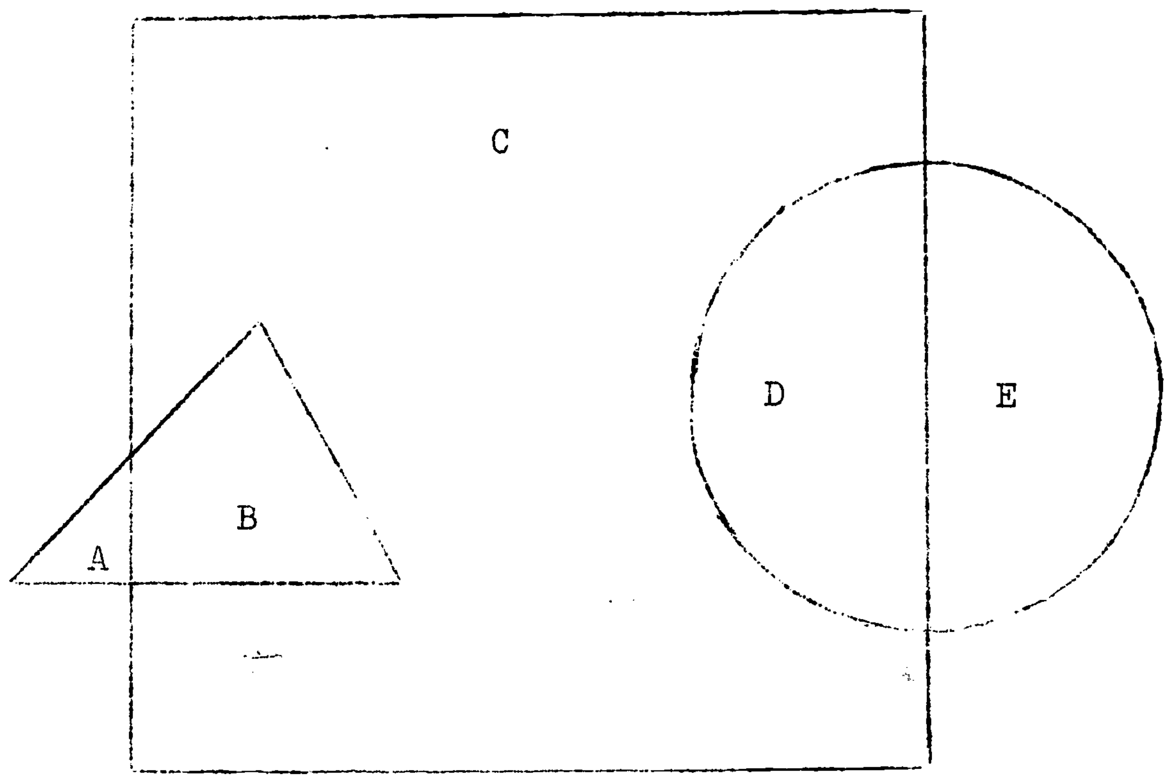
In the figure a rectangle, a triangle and a circle have been superimposed such that areas A, B, C, D, and E are defined. B, C, and D are all separate areas even though they also belong to the rectangle.

One of these areas has been chosen at random; you should determine which of the areas has been selected.

Questions	Answers
1. Is it the smallest area?	1. No
2. Is it the largest area?	2. No
3. Does it have one curved side?	3. No
4. Does it have two or more sides?	4. Yes

Solution: Area B.

Appendix I



Figur zu Aufgabe 29A

ANTWORTBLATT

Aufgabe 29A

Nummer der Frage

1. ________

2. ________

3. ________

4. ________

Antwort: ________

Aufgabe 31A*

Instructions and Corresponding Questions and Answers

An der gemischten Kantonsschule von Wetzikon soll ein Schulfest stattfinden. Ein Schülerkomitee aus Mädchen und Knaben wurde bestimmt um das Fest zu organisieren. Knaben und Mädchen sind an dem Komitee beteiligt. Ein Teil von ihnen besorgt die Getränke, und ein anderer Teil erledigt den Verkauf der Eintrittskarten. Die Liste der Mädchen des Komitees für den Eintrittskartenverkauf ist verloren gegangen. Mit den zusätzlichen Angaben, die in den Fragen gegeben sind, sollst du die Anzahl der Mädchen, die den Verkauf der Eintrittskarten übernommen haben, bestimmen.

Fragen	Antworten
1. Ist Wetzikon die einzige gemischte Mittelschule im Kanton Zürich?	1. Nein.
2. Wieviele Knaben besuchen die Kantonsschule Wetzikon?	2. 240.
3. Wieviele Knaben sind im Fest-Komitee?	3. 10.
4. Hat es mehr Knaben als Mädchen in dieser Schule?	4. Ja.
5. Wieviele Schüler des Fest-Komitees wurden für die Beschaffung der Getränke bestimmt?	5. 14.
6. Welches ist die Gesamtzahl der Schüler im Fest-Komitee?	6. 25.
7. Wieviel Zeit braucht das Komitee insgesamt für die Vorbereitungen des Festes?	7. 275 Stunden
8. Wieviel Zeit entfällt durchschnittlich auf ein Komiteemitglied?	8. 11 Stunden.
9. Wieviele Knaben im Komitee beschäftigen sich mit dem Verkauf der Eintrittskarten?	9. 6.
10. Wieviele Mädchen des Fest-Komitees kümmern sich um die Getränke?	10. 10.

Solution: 5

* English translations for this and the remaining Loyola Problems can be found in Rimoldi _et al_. (19).

Appendix I

Aufgabe 31B

Instructions and Corresponding Questions and Answers

Es gibt eine gewisse Anzahl von Gegenständen: M. Ein Teil davon sind Cs. Die Cs setzen sich aus Bs und Gs zusammen. Jede dieser beiden letzten Arten unterteilen sich in Rs und Ts. Mit den zusätzlichen Angaben, die in den Fragen gegeben sind, sollst du herausfinden, welche Anzahl der Gs ebenfalls Ts sind.

Fragen	Antworten
1. Gibt es Cs, die nicht Bs und Gs sind?	1. Nein.
2. Wieviele Bs sind Cs?	2. 30.
3. Wieviele Bs sind Ms?	3. 120.
4. Wieviele Cs sind Rs?	4. 35.
5. Gibt es mehr Gs als Bs unter den Ms?	5. Ja.
6. Wieviel gibt k mal die Cs?	6. 550.
7. Welches ist die Gesamtzahl der Cs?	7. 50.
8. Wieviele Bs, die Cs sind, sind ebenfalls Ts?	8. 10.
9. Wieviele Gs, die Cs sind, sind ebenfalls Rs?	9. 15.
10. Wie gross ist k?	10. 11.

Solution: 5

Aufgabe 31D

Instructions and Corresponding Questions and Answers

Von R Gegenständen wurden L ausgewählt. Diese L Gegenstände sind in As und Bs unterteilt. Jede dieser beiden letzten Arten sind in Ms und Ns unterteilt. Mit den zusätzlichen Angaben, die in den Fragen gegeben sind, sollst du herausfinden, welche Anzahl der Ns ebenfalls Bs sind.

Fragen	Antworten
1. Wieviele As sind Rs ?	1. W.
2. Welches ist die Gesamtzahl der Ls?	2. E + F + H + I = P + Q = L.
3. Wieviele Ls sind Ms?	3. E + F = X
4. Wieviele As sind Ls?	4. E + H = P.
5. Gibt es mehr Bs als As unter den Rs?	5. Ja.
6. Gibt es Ls, die nicht Bs und As sind?	6. Nein.
7. Wieviele Bs, die L sind, sind ebenfalls M?	7. F.
8. Wieviele As, die L sind, sind ebenfalls N?	8. H.
9. Wie gross ist k?	9. T.
10. Wieviel gibt k mal die Ls?	10. Z.

Solution: I

Aufgabe 42

Instructions and Corresponding Questions and Answers

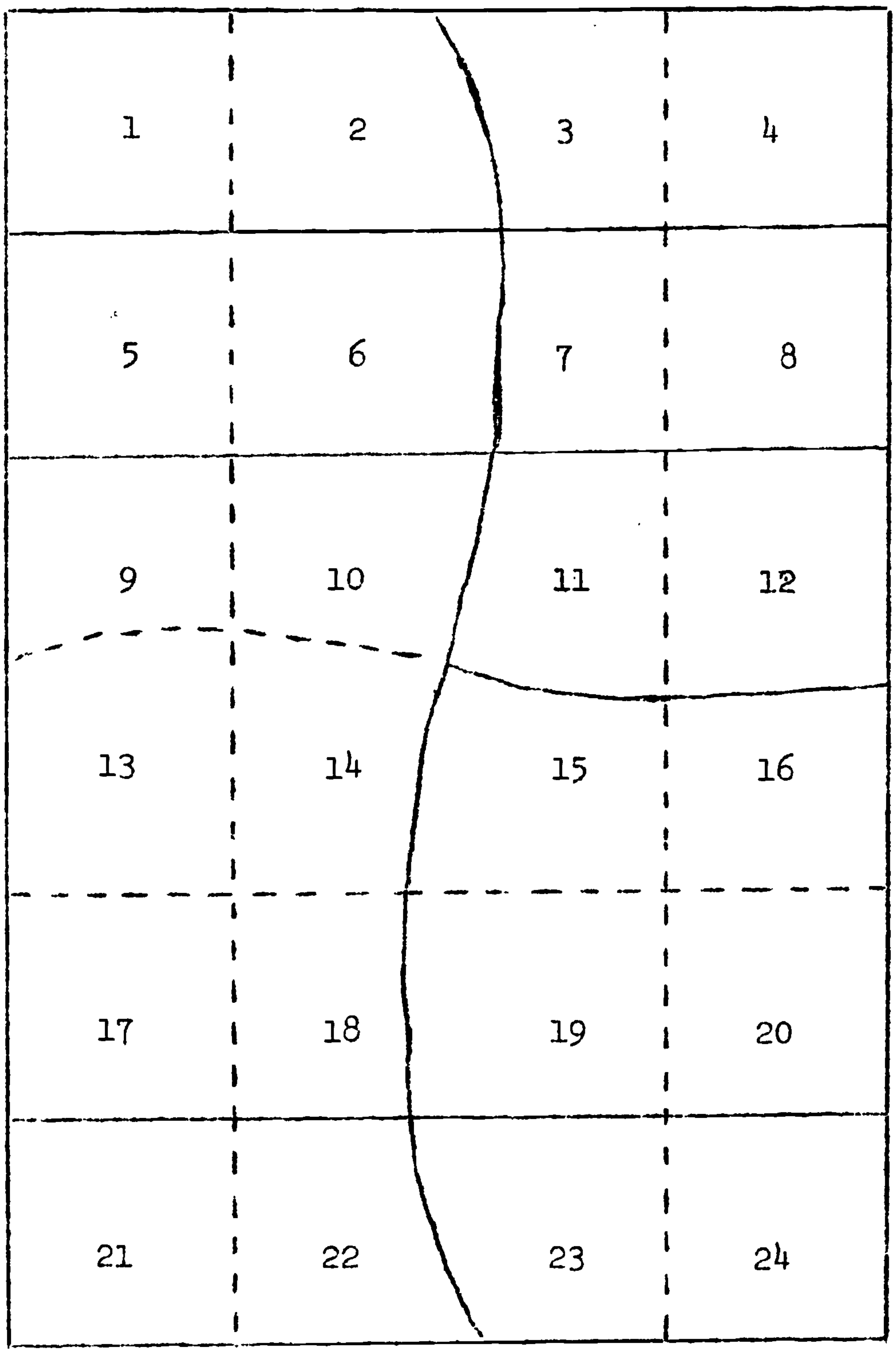
Die Figur besteht aus 24 Feldern. Die Zahlen in den Feldern dienen nur zu ihrer Bezeichnung, und sie haben keinen Einfluss auf die Lösung der Aufgabe. Eines dieser Felder wurde ausgewählt; es ist deine Aufgabe herauszufinden, welches Feld bestimmt wurde. Dies ist möglich, indem du jene Fragen stellst, die du für die Lösung des Problems als notwendig erachtest.

Fragen	Antworten
1. Liegt es oberhalb der nicht unterbrochenen gebogenen Linie?	1. Nein.
2. Hat es zwei gebogene Linien als Begrenzung?	2. Nein.
3. Liegt es rechts von der senkrechten gebogenen Linie?	3. Ja.
4. Hat es zwei durchgezogene gerade Linien und zwei gestrichelte Linien als Berenzung?	4. Nein.
5. Hat es zwei gestrichelte gerade Linien als Begrenzung?	5. Nein.
6. Hat es irgendeine Kombination von swei gestrichelten und zwei gebogenen Seiten?	6. Nein.
7. Liegt es unterhalb der punktierten gebogenen Linie?	7. Nein.
8. Hat es drei durchgezogene gerade Linien und eine gestrichelte gerade Linie als Bergrenzung?	8. Nein.
9. Hat es eine gestrichelte gebogene Linie als Begrenzung?	9. Nein.
10. Hat es mindestens eine nicht unterbrochene gerade Linie und zwei durchgezogene gebogene Linien als Begrenzung?	10. Nein.

Solution: Feld 23

Appemdix I

AUFGABE 42



Aufgabe 35A

Instructions and Corresponding Questions and Answers

Die Chorgruppe eines Gymnasiums besteht aus Schülern der ersten, dritten und fünften Klasse. Der Chor hat drei verschiedene Stimmlagen: die hohe, die mittlere und die tiefe Stimme. Die untenstehenden Fragen und Antworten enthalten wichtige Angaben über diese Gruppe. Mit diesen Angaben musst du herausfinden, wieviele Schüler der funften Klasse die mittlere Stimme singen.

Fragen	Antworten
1. Wieviele Fünftklässler hat es in der Schule?	1. 1567.
2. Wieviele Erstklässler sind im Chor?	2. 23.
3. Wieviele Drittklässler singen die mittlere Stimme?	3. 10.
4. Wieviele Mitglieder hat der Chor?	4. 76.
5. Wieviele Mädchen sind im Chor?	5. 45.
6. Wieviele Drittklässler sind im Chor?	6. 28.
7. Wieviele Fünftklässler singen die hohe Stimme?	7. 7.
8. Wieviele Erstklässler hat es in der Schule?	8. 1848.
9. Wieviele Erstklässler singen die hohe Stimme?	9. 8.
10. Wieviele Mitglieder singen die tiefe Stimme?	10. 28.
11. Wieviele Drittklässler singen die hohe Stimme?	11. 9.
12. Wieviele Klaviere besitzt der Chor?	12. 3.
13. Wieviele Erstklässler singen die tiefe Stimme?	13. 9.
14. Wieviele Mitglieder des Chors singen die hohe Stimme?	14. 24.
15. Wieviele Funftklässler singen in der Gruppe der tiefen Stimme?	15. 10.
16. Wieviele Erstklässler singen die mittlere Stimme?	16. 6.
17. Wieviele Drittklässler singen die tiefe Stimme?	17. 9.

Solution: 8

Aufgabe 35B

Instructions and Corresponding Questions and Answers

T Gegenstände setzen sich zusammen aus den Arten M, N und P. Jede dieser letzten dreiArten ist unterteilt in Qs, Rs und Ws. Mit Hilfe der Fragen und Antworten kannst du die verschiedenen Beziehungen zwischen diesen Gegenständen herausfinden. Benütze diese Angaben um zu bestimmen, wieviele der T Gegenstände Ns und ebenfalls Ws sind.

Fragen	Antworten
1. Wieviele Ws sind As?	1. 350.
2. Wieviele Qs gibt es unter den Ts?	2. 19.
3. Wieviele Gs gibt es unter den Ts?	3. 43.
4. Wieviele Rs sind ebenfalls Ns?	4. 8.
5. Welches ist die Gesamtzahl der T Gegenstände?	5. 63.
6. Wieviele Ps gibt es unter den Ts?	6. 21.
7. Wieviele Rs gibt es unter den Ts?	7. 24.
8. Wieviele Qs sind ebenfalls Ms?	8. 5.
9. Wieviele Rs sind ebenfalls Ms?	9. 10.
10. Wieviele Ws sind ebenfalls Ms?	10. 2.
11. Wieviele Qs sind As?	11. 400.
12. Wieviele Rs sind ebenfalls Ps?	12. 6.
13. Wieviele Qs sind ebenfalls Ns?	13. 3.
14. Wieviele Ws sind ebenfalls Ps?	14. 4.
15. Wieviele Ms gibt es unter den Ts?	15. 17.
16. Wieviele Qs sind ebenfalls Ps?	16. 11.
17. Wieviele Hs gibt es unter den As?	17. 2.

Solution: 14

Appendix I

Aufgabe 35D

Instructions and Corresponding Questions and Answers

Eine Gruppe von L Gegenständen setzt sich aus den Arten A, B, und C zusammen. Jede dieser letzten drei Arten ist unterteilt in Ds, Es und Fs. Mit Hilfe der untenstehenden Fragen und Antworten kannst du die verschiedenen Beziehungen zwischen diesen Gegenständen herausfinden. Benütze diese Angaben um zu bestimmen, wieviele der L Gegenstände Bs und ebenfalls Fs sind.

	Fragen		Antworten
1.	Wieviele Fs hat es in J?	1.	U
2.	Wieviele Ls sind Ds?	2.	M + N + O = X
3.	Welches ist die Gesamtzahl der Ls?	3.	M + N + O + R + Q + P + S + T + V = X + Y + Z = G + H + I = L
4.	Wieviele Es sind Bs?	4.	Q
5.	Wieviele Ls sind Ks?	5.	W
6.	Wieviele Ds hat es in M?	6.	X - M + O
7.	Wieviele Ls sind Es?	7.	R + Q + P = Y
8.	Wieviele Fs sind As?	8.	S
9.	Wieviele Es sind As?	9.	R
10.	Wieviele Ds sind As?	10.	M
11.	Wieviele Ls sind Cs?	11.	O + P + V = I
12.	Wieviele Fs sind Cs?	12.	V
13.	Wieviele Ls sind As?	13.	M + R + S = G
14.	Wieviele Ds sind Cs?	14.	O
15.	Wieviele Us sind Ms?	15.	U - J
16.	Wieviele Ds sind Bs?	16.	N
17.	Wieviele Es sind Cs?	17.	P

Solution: T

Appendix I

(Sample Answer Sheet)

ANTWORTBLATT

Name ______________________ Datum ______________________

Reihenfolge der Aufgaben: 31A, 31B, 31D, 42, 35A, 35B, 35D

Aufgabe 31A Nummer der Frage	Aufgabe 31B Nummer der Frage	Aufgabe 31D Nummer der Frage	Aufgabe 42 Nummer der Frage
1. ______	1. ______	1. ______	1. ______
2. ______	2. ______	2. ______	2. ______
3. ______	3. ______	3. ______	3. ______
4. ______	4. ______	4. ______	4. ______
5. ______	5. ______	5. ______	5. ______
6. ______	6. ______	6. ______	6. ______
7. ______	7. ______	7. ______	7. ______
8. ______	8. ______	8. ______	8. ______
9. ______	9. ______	9. ______	9. ______
10. ______	10. ______	10. ______	10. ______
Antwort: ____	Antwort: ____	Antwort: ____	Antwort: ____

Aufgabe 35A Nr. der Frage	Aufgabe 35B Nr. der Frage	Aufgabe 35D Nr. der Frage
1. ______	1. ______	1. ______
2. ______	2. ______	2. ______
3. ______	3. ______	3. ______
4. ______	4. ______	4. ______
5. ______	5. ______	5. ______
6. ______	6. ______	6. ______
7. ______	7. ______	7. ______
8. ______	8. ______	8. ______
9. ______	9. ______	9. ______
10. ______	10. ______	10. ______
11. ______	11. ______	11. ______
12. ______	12. ______	12. ______
13. ______	13. ______	13. ______
14. ______	14. ______	14. ______
15. ______	15. ______	15. ______
16. ______	16. ______	16. ______
17. ______	17. ______	17. ______
Antwort: ____	Antwort: ____	Antwort: ____

Appendix I

KOMBINATIONEN (Piaget Experiment -- testing version)

Name: geb. Kl. Lehrer:

Anweisung: Hier sind sechs verschiedene Häufchen Flöhe; stelle dir vor jedes Häufchen sei eine Gruppe Kinder aus verschiedenen Ländern: Ch, Italien etc. Diese Kinder gehen miteinander spazieren, und swar immer zwei zusammen, also in Paaren. Es hat zwei Bedingungen: es hat nie zwei Kinder der gleichen Nation in einem Paar, und jedes Paar ist von allen andern verschieden: d. h. keine Paare dürfen die gleichen zwei Nationen haben.

Wiederhole bitte die Anweisung.

Nachdem der erste Floh gelegt ist: Hast du einen Plan, wie du es machen willst?

1. Wie bist du zu diesem Resultat gekommen?

2. Könnte man im Kopf ausrechnen, wie viele Paare es geben muss?

3. Bist du zufrieden mit deinem Resultat?

4. Wenn du die Paare noch einmal legen müsstest, würdest du es gleich machen wie eben, oder würdest du etwas ändern?

Check Liste

System:

1. welcher Art
2. antizipiert
3. angewendet und ganz durchgeführt
4. verallgemeinert
5. empirisch gefunden
6. quantifiziert
7. Aenderungen

Appendix II

COMBINATION (Piaget Experiment -- English translation)

Name: born class teacher:

Instructions: There are six different heaps of chips; just imagine that each heap is a group of children from different countries: Switzerland, Italy, etc. These children go for a walk together, always two together, i.e. in pairs. There are two conditions: there are never two kids of the same nation in one pair and each pair is different from all the others: i.e. no pairs must include the same 2 nations.

Please repeat the instructions.

After having put down the first chip: Do you have a plan, how you want to do it?

1. How did you get this result?

2. Could you calculate in your head, how many pairs there must be?

3. Are you satisfied with your result?

4. If you could lay out the chips once more, would you do it the same way, or would you change something?

Check List

System:

1. Which kind
2. Anticipated
3. Applied and carried out
4. Generalized
5. Empirically found
6. Quantified
7. Changes

Appendix II

WAHRSCHEINLICHKEITEN (Piaget Experiment -- testing version)

Name: geb. Kl. Lehrer:

Anweisung: Wir haben zwei Häufchen Flöhe: ein Teil ist ganz gelb, der andere ist gemustert. Für jede Frage stellen wir diese zwei Arten Flöhe anders zusammen: jedes Häufchen wird aus beiden Arten zusammengesetzt sein. Du musst dann angeben, aus welchem Häufchen du E H E R einen gemusterten Floh ziehen kannst mit einem Zug.

Wiederhole bitte die Aufgabe.

Halte nun bitte diesen Karton, damit ich die erste Aufgabe vorbereiten kann.

1. 2/4 // 0/4

2. 3/6 // 6/6

3. 4/8 // 4/8

4. 2/4 // 4/8

5. 1/4 // 2/4

6. 2/4 // 2/6

7. 4/7 // 2/3

8. 2/4 // 4/6

9. 4/4 // 6/6

Check Liste

Proportionalitäten

Prop. und Häuf. in Beziehung gesetzt

Häufigkeiten

Appendix II

PROBABILITIES (Piaget Experiment -- English translation)

Name: born class teacher:

Instructions: There are two types of chips: one part is yellow, the other is checkered. For each item we compose these two heaps of chips differently: each heap will contain both kinds. You must then indicate from which heap you would r a t h e r draw, if you had to draw a checkered chip in one try.

Please repeat the instructions.

Now please hold this paper so that I can prepare the first item.

1. 2/4 // 0/4

2. 3/6 // 6/6

3. 4/8 // 4/8

4. 2/4 // 4/8

5. 1/4 // 2/4

6. 2/4 // 2/6

7. 4/7 // 2/3

8. 2/4 // 4/6

9. 4/4 // 6/6

Check List

Proportionalities

Frequencies

Proportionalities and frequencies in relation

Appendix II

GLEICHGEWICHT (Piaget Experiment -- testing version)

Name: geb. Kl. Lehrer:

Anweisung: Hier hat es einen hölzernen Stab mit Löchern, und er wird in der Mitte aufgehängt. Du siehst dass er genau waagrecht aufliegt. Wenn du Gewichte an den Stab hängst, ist er vielleicht nicht mehr waagrecht. Wenn dies geschieht, sollst de den Stab wieder in die waagrechte Lage bringen.

(Gewichte: A = 50 gr.; B = 100 gr.; C = 200 gr.)

Du darfst jederzeit Fragen stellen.

1. C2 A5

   Vertausche die Gewichte, doch bewahre das Gleichgewicht

2. A6 A4

3. A5 B5

4. A7 A7

5. B6 A2 C1 A4

6. C4 A4 A4 B4

Check Liste

Erster Lösungsversuch in sinnvoller Richtung ja/nein spätere Fehler

allgemeine Richtung oder ein bestimmtes Loch

Kenntnis der Werte der Gewichte ja/nein in Relationen oder in Zahlen

Erklärung des Gleichgewichtes durch Gewicht Distanz Kombination von G und D

falls beide Variablen berücksichtigt: qualitativ quatitativ

Appendix II

BALANCE (Piaget Experiment - English translation)

Name: born class teacher:

Instructions: Here is a wooden bar with holes in it, and it will be suspended in the middle. You see that it is exactly in equilibrium. If you hang weights onto the bar, it is perhaps no longer in equilibrium. If this happens, you must reestablish the equilibrium of the bar.

(Weights: A = 50 gr.; B = 100 gr.; C = 200 gr.)

You may ask questions any time. Predict what will happen before I let go.

1. C2 A5

   Exchange the weights, but maintain the equilibrium.

2. A6 A4

3. A5 B5

4. A7 A7

5. B6 A2 C1 A4

6. C4 A4 A4 B4

Check List

First move in correct direction yes/no later mistakes

General direction or one particular hole

Knowledge of the values of the weights yes/no in relations or in numbers

Explanation of equilibrium by weight distance combination of weight and distance

If both variables considered: qualitative quantitative

Appendix II

Table 18

Summary of Analysis of Variance for Quartiles of First Amthauer Subtest (Factor A) by Scoring Methods (Factor B) Based on Loyola Problem 31A.

Source	SS	DF	MS	F
Between Ss	52.827	263.000	0.000	0.000
A	9.312	3.000	3.104	18.546**
Subjs. w. grps.	43.515	260.000	0.167	0.000
Within Ss	5.367	528.000	0.000	0.000
B	2.030	2.000	1.015	160.316**
AB	0.044	6.000	0.007	1.161
Bx Subj. w. grps.	3.292	520.000	0.006	0.000

Table 19

Summary of Analysis of Variance for Quartiles of First Amthauer Subtest (Factor A) by Scoring Methods (Factor B) Based on Loyola Problem 31B.

Source	SS	DF	MS	F
Between Ss	40.525	263.000	0.000	0.000
A	4.093	3.000	1.364	9.735**
Subjs. w. grps.	36.433	260.000	0.140	0.000
Within Ss	5.388	528.000	0.000	0.000
B	2.327	2.000	1.163	200.013**
AB	0.037	6.000	0.006	1.066
Bx Subj. w. grps.	3.025	520.000	0.006	0.000

* $p < .05$

** $p < .01$

This designation is appropriate throughout the Appendix.

Table 20

Summary of Analysis of Variance for Quartiles of First Amthauer Subtest (Factor A) by Scoring Methods (Factor B) Based on Loyola Problem 31D.

Source	SS	DF	MS	F
Between Ss	40.373	263.000	0.000	0.000
A	1.694	3.000	0.565	3.796*
Subjs. w. grps.	38.679	260.000	0.149	0.000
Within Ss	5.819	528.000	0.000	0.000
B	1.848	2.000	0.924	121.191**
AB	0.005	6.000	0.001	0.106
Bx Subj. w. grps.	3.965	520.000	0.008	0.000

Table 21

Summary of Analysis of Variance for Quartiles of First Amthauer Subtest (Factor A) by Scoring Methods (Factor B) Based on Loyola Problem 42.

Source	SS	DF	MS	F
Between Ss	26.623	263.000	0.000	0.000
A	1.069	3.000	0.356	3.625*
Subjs. w. grps.	25.554	260.000	0.098	0.000
Within Ss	10.736	528.000	0.000	0.000
B	7.161	2.000	3.581	522.399**
AB	0.011	6.000	0.002	0.265
Bx Subj. w. grps.	3.564	520.000	0.007	0.000

Table 22

Summary of Analysis of Variance for Quartiles of First Amthauer Subtest (Factor A) by Scoring Methods (Factor B) Based on Loyola Problem 35A.

Source	SS	DF	MS	F
Between Ss	63.806	263.000	0.000	0.000
A	6.970	3.000	2.323	10.629**
Subjs. w. grps.	56.835	260.000	0.219	0.000
Within Ss	5.804	528.000	0.000	0.000
B	1.886	2.000	0.943	126.076**
AB	0.027	6.000	0.005	0.611
Bx Subj. w. grps.	3.890	520.000	0.007	0.000

Table 23

Summary of Analysis of Variance for Quartiles of First Amthauer Subtest (Factor A) by Scoring Methods (Factor B) Based on Loyola Problem 35B.

Source	SS	DF	MS	F
Between Ss	57.656	263.000	0.000	0.000
A	2.526	3.000	0.842	3.971**
Subjs. w. grps.	55.130	260.000	0.212	0.000
Within Ss	3.062	528.000	0.000	0.000
B	0.202	2.000	0.101	18.478**
AB	0.022	6.000	0.004	0.663
Bx Subj. w. grps.	2.838	520.000	0.005	0.000

Table 24

Summary of Analysis of Variance for Quartiles of First Amthauer Subtest (Factor A) by Scoring Methods (Factor B) Based on Loyola Problem 35D.

Source	SS	DF	MS	F
Between Ss	56.335	263.000	0.000	0.000
A	3.210	3.000	1.070	5.237**
Subjs. w. grps.	53.125	260.000	0.204	0.000
Within Ss	3.599	528.000	0.000	0.000
B	0.335	2.000	0.168	26.755**
AB	0.008	6.000	0.001	0.211
Bx Subj. w. grps.	3.256	520.000	0.006	0.000

Table 25

Summary of Analysis of Variance for Quartiles of Second Amthauer Subtest (Factor A) by Scoring Methods (Factor B) Based on Loyola Problem 31A.

Source	SS	DF	MS	F
Between Ss	52.827	263.000	0.000	0.000
A	5.739	3.000	1.913	10.562**
Subjs. w. grps.	47.088	260.000	0.181	0.000
Within Ss	5.367	528.000	0.000	0.000
B	2.030	2.000	1.015	158.343**
AB	0.003	6.000	0.001	0.080
Bx Subj. w. grps.	3.333	520.000	0.006	0.000

Table 26

Summary of Analysis of Variance for Quartiles of Second Amthauer Subtest (Factor A) by Scoring Methods (Factor B) Based on Loyola Problem 31B.

Source	SS	DF	MS	F
Between Ss	40.525	263.000	0.000	0.000
A	4.030	3.000	1.343	9.571**
Subjs. w. grps.	36.495	260.000	0.140	0.000
Within Ss	5.388	528.000	0.000	0.000
B	2.327	2.000	1.163	200.461**
AB	0.044	6.000	0.007	1.262
Bx Subj. w. grps.	3.018	520.000	0.006	0.000

Table 27

Summary of Analysis of Variance for Quartiles of Second Amthauer Subtest (Factor A) by Scoring Methods (Factor B) Based on Loyola Problem 31D.

Source	SS	DF	MS	F
Between Ss	40.373	263.000	0.000	0.000
A	3.639	3.000	1.213	8.585**
Subjs. w. grps.	36.734	260.000	0.141	0.000
Within Ss	5.819	528.000	0.000	0.000
B	1.848	2.000	0.924	122.003**
AB	0.031	6.000	0.005	0.688
Bx Subj. w. grps.	3.939	520.000	0.008	0.000

Appendix III

Table 28

Summary of Analysis of Variance for Quartiles of Second Amthauer Subtest (Factor A) by Scoring Methods (Factor B) Based on Loyola Problem 42.

Source	SS	DF	MS	F
Between Ss	26.623	263.000	0.000	0.000
A	1.281	3.000	0.427	4.380**
Subjs. w. grps.	25.342	260.000	0.097	0.000
Within Ss	10.736	528.000	0.000	0.000
B	7.161	2.000	3.581	526.875**
AB	0.041	6.000	0.007	1.011
Bx Subj. w. grps.	3.534	520.000	0.007	0.000

Table 29

Summary of Analysis of Variance for Quartiles of Second Amthauer Subtest (Factor A) by Scoring Methods (Factor B) Based on Loyola Problem 35A.

Source	SS	DF	MS	F
Between Ss	63.806	263.000	0.000	0.000
A	9.155	3.000	3.052	14.517**
Subjs. w. grps.	54.651	260.000	0.210	0.000
Within Ss	5.804	528.000	0.000	0.000
B	1.886	2.000	0.943	125.512**
AB	0.010	6.000	0.002	0.221
Bx Subj. w. grps.	3.908	520.000	0.008	0.000

Appendix III

Table 30

Summary of Analysis of Variance for Quartiles of Second Amthauer Subtest (Factor A) by Scoring Methods (Factor B) Based on Loyola Problem 35B.

Source	SS	DF	MS	F
Between Ss	57.656	263.000	0.000	0.000
A	2.831	3.000	0.944	4.476**
Subjs. w. grps.	54.824	260.000	0.211	0.000
Within Ss	3.062	528.000	0.000	0.000
B	0.202	2.000	0.101	18.448**
AB	0.017	6.000	0.003	0.522
Bx Subj. w. grps.	2.843	520.000	0.005	0.000

Table 31

Summary of Analysis of Variance for Quartiles of Second Amthauer Subtest (Factor A) by Scoring Methods (Factor B) Based on Loyola Problem 35D.

Source	SS	DF	MS	F
Between Ss	56.335	263.000	0.000	0.000
A	3.549	3.000	1.183	5.827**
Subjs. w. grps.	52.786	260.000	0.203	0.000
Within Ss	3.599	528.000	0.000	0.000
B	0.335	2.000	0.168	27.045**
AB	0.043	6.000	0.007	1.155
Bx Subj. w. grps.	3.221	520.000	0.006	0.000

Table 32

Summary of Analysis of Variance for Quartiles of Third Amthauer Subtest (Factor A) by Scoring Methods (Factor B) Based on Loyola Problem 31A.

Source	SS	DF	MS	F
Between Ss	52.827	263.000	0.000	0.000
A	11.302	3.000	3.767	23.589**
Subjs. w. grps.	41.525	260.000	0.160	0.000
Within Ss	5.367	528.000	0.000	0.000
B	2.030	2.000	1.015	159.400**
AB	0.025	6.000	0.004	0.660
Bx Subj. w. grps.	3.311	520.000	0.006	0.000

Table 33

Summary of Analysis of Variance for Quartiles of Third Amthauer Subtest (Factor A) by Scoring Methods (Factor B) Based on Loyola Problem 31B.

Source	SS	DF	MS	F
Between Ss	40.525	263.000	0.000	0.000
A	5.694	3.000	1.898	14.167**
Subjs. w. grps.	34.832	260.000	0.134	0.000
Within Ss	5.388	528.000	0.000	0.000
B	2.327	2.000	1.163	199.352**
AB	0.027	6.000	0.005	0.776
Bx Subj. w. grps.	3.035	520.000	0.006	0.000

Table 34

Summary of Analysis of Variance for Quartiles of Third Amthauer Subtest (Factor A) by Scoring Methods (Factor B) Based on Loyola Problem 31D.

Source	SS	DF	MS	F
Between Ss	40.373	263.000	0.000	0.000
A	4.080	3.000	1.360	9.743**
Subjs. w. grps.	36.293	260.000	0.140	0.000
Within Ss	5.819	528.000	0.000	0.000
B	1.848	2.000	0.924	121.650**
AB	0.020	6.000	0.003	0.437
Bx Subj. w. grps.	3.950	520.000	0.008	0.000

Table 35

Summary of Analysis of Variance for Quartiles of Third Amthauer Subtest (Factor A) by Scoring Methods (Factor B) Based on Loyola Problem 42

Source	SS	DF	MS	F
Between Ss	26.623	263.000	0.000	0.000
A	2.000	3.000	0.667	7.041**
Subjs. w. grps.	24.622	260.000	0.095	0.000
Within Ss	10.736	528.000	0.000	0.000
B	7.161	2.000	3.581	522.018**
AB	0.008	6.000	0.001	0.202
Bx Subj. w. grps.	3.567	520.000	0.007	0.000

Table 36

Summary of Analysis of Variance for Quartiles of Third Amthauer Subtest (Factor A) by Scoring Methods (Factor B) Based on Loyola Problem 35A.

Source	SS	DF	MS	F
Between Ss	63.806	263.000	0.000	0.000
A	11.222	3.000	3.741	18.497**
Subjs. w. grps.	52.583	260.000	0.202	0.000
Within Ss	5.804	528.000	0.000	0.000
B	1.886	2.000	0.943	125.578**
AB	0.012	6.000	0.002	0.267
Bx Subj. w. grps.	3.906	520.000	0.008	0.000

Table 37

Summary of Analysis of Variance for Quartiles of Third Amthauer Subtest (Factor A) by Scoring Methods (Factor B) Based on Loyola Problem 35B.

Source	SS	DF	MS	F
Between Ss	57.656	263.000	0.000	0.000
A	3.296	3.000	1.099	5.254**
Subjs. w. grps.	54.360	260.000	0.209	0.000
Within Ss	3.062	528.000	0.000	0.000
B	0.202	2.000	0.101	18.673**
AB	0.051	6.000	0.009	1.588
Bx Subj. w. grps.	2.809	520.000	0.005	0.000

Table 38

Summary of Analysis of Variance for Quartiles of Third Amthauer Subtest (Factor A) by Scoring Methods (Factor B) Based on Loyola Problem 35D.

Source	SS	DF	MS	F
Between Ss	56.335	263.000	0.000	0.000
A	4.759	3.000	1.586	7.996**
Subjs. w. grps.	51.577	260.000	0.198	0.000
Within Ss	3.599	528.000	0.000	0.000
B	0.335	2.000	0.168	26.787**
AB	0.012	6.000	0.002	0.317
Bx Subjs. w. grps.	3.252	520.000	0.006	0.000

Appendix III

Table 39

Summary of Analysis of Variance for Quartiles of Fourth Amthauer Subtest (Factor A) by Scoring Methods (Factor B) Based on Loyola Problem 31A.

Source	SS	DF	MS	F
Between Ss	52.827	263.000	0.000	0.000
A	10.254	3.000	3.418	20.875**
Subjs. w. grps.	42.573	260.000	0.164	0.000
Within Ss	5.367	528.000	0.000	0.000
B	2.030	2.000	1.015	158.600**
AB	0.008	6.000	0.001	0.221
Bx Subj. w. grps.	3.328	520.000	0.006	0.000

Table 40

Summary of Analysis of Variance for Quartiles of Fourth Amthauer Subtest (Factor A) by Scoring Methods (Factor B) Based on Loyola Problem 31B.

Source	SS	DF	MS	F
Between Ss	40.525	263.000	0.000	0.000
A	3.344	3.000	1.115	7.795**
Subjs. w. grps.	37.181	260.000	0.143	0.000
Within Ss	5.388	528.000	0.000	0.000
B	2.327	2.000	1.163	202.578**
AB	0.075	6.000	0.013	2.191*
Bx Subj. w. grps.	2.986	520.000	0.006	0.000

Table 41

Summary of Analysis of Variance for Quartiles of Fourth Amthauer Subtest (Factor A) by Scoring Methods (Factor B) Based on Loyola Problem 31D.

Source	SS	DF	MS	F
Between Ss	40.373	263.000	0.000	0.000
A	4.730	3.000	1.577	11.502**
Subjs. w. grps.	35.643	260.000	0.137	0.000
Within Ss	5.819	528.000	0.000	0.000
B	1.848	2.000	0.924	122.197**
AB	0.038	6.000	0.006	0.827
Bx Subj. w. grps.	3.933	520.000	0.008	0.000

Appendix III

Table 42

Summary of Analysis of Variance for Quartiles of Fourth Amthauer Subtest (Factor A) by Scoring Methods (Factor B) Based on Loyola Problem 42.

Source	SS	DF	MS	F
Between Ss	26.623	263.000	0.000	0.000
A	1.427	3.000	0.476	4.907**
Subjs. w. grps.	25.196	260.000	0.097	0.000
Within Ss	10.736	528.000	0.000	0.000
B	7.161	2.000	3.581	521.721**
AB	0.006	6.000	0.001	0.153
Bx Subj. w. grps.	3.569	520.000	0.007	0.000

Table 43

Summary of Analysis of Variance for Quartiles of Fourth Amthauer Subtest (Factor A) by Scoring Methods (Factor B) Based on Loyola Problem 35A.

Source	SS	DF	MS	F
Between Ss	63.806	263.000	0.000	0.000
A	6.633	3.000	2.211	10.055**
Subjs. w. grps.	57.173	260.000	0.220	0.000
Within Ss	5.804	528.000	0.000	0.000
B	1.886	2.000	0.943	125.682**
AB	0.015	6.000	0.003	0.339
Bx Subj. w. grps.	3.903	520.000	0.008	0.000

Table 44

Summary of Analysis of Variance for Quartiles of Fourth Amthauer Subtest (Factor A) by Scoring Methods (Factor B) Based on Loyola Problem 35B.

Source	SS	DF	MS	F
Between Ss	57.656	263.000	0.000	0.000
A	2.527	3.000	0.842	3.972**
Subjs. w. grps.	55.129	260.000	0.212	0.000
Within Ss	3.062	528.000	0.000	0.000
B	0.202	2.000	0.101	18.900**
AB	0.085	6.000	0.014	2.659*
Bx Subj. w. grps.	2.775	520.000	0.005	0.000

Table 45

Summary of Analysis of Variance for Quartiles of Fourth Amthauer Subtest (Factor A) by Scoring Methods (Factor B) Based on Loyola Problem 35D.

Source	SS	DF	MS	F
Between Ss	56.335	263.000	0.000	0.000
A	2.811	3.000	0.937	4.551**
Subjs. w. grps.	53.525	260.000	0.206	0.000
Within Ss	3.599	528.000	0.000	0.000
B	0.335	2.000	0.168	26.812**
AB	0.015	6.000	0.002	0.398
Bx Subj. w. grps.	3.249	520.000	0.006	0.000

Table 46

Summary of Analysis of Variance for Quartiles of Fifth Amthauer Subtest (Factor A) by Scoring Methods (Factor B) Based on Loyola Problem 31A.

Source	SS	DF	MS	F
Between Ss	52.827	263.000	0.000	0.000
A	10.993	3.000	3.664	22.774**
Subjs. w. grps.	41.834	260.000	0.161	0.000
Within Ss	5.367	528.000	0.000	0.000
B	2.030	2.000	1.015	158.941**
AB	0.016	6.000	0.003	0.409
Bx Subj. w. grps.	3.321	520.000	0.006	0.000

Table 47

Summary of Analysis of Variance for Quartiles of Fifth Amthauer Subtest (Factor A) by Scoring Methods (Factor B) Based on Loyola Problem 31B.

Source	SS	DF	MS	F
Between Ss	40.525	263.000	0.000	0.000
A	3.366	3.000	1.122	7.851**
Subjs. w. grps.	37.159	260.000	0.143	0.000
Within Ss	5.388	528.000	0.000	0.000
B	2.327	2.000	1.163	199.194**
AB	0.025	6.000	0.004	0.705
Bx Subj. w. grps.	3.037	520.000	0.006	0.000

Table 48

Summary of Analysis of Variance for Quartiles of Fifth Amthauer Subtest (Factor A) by Scoring Methods (Factor B) Based on Loyola Problem 31D.

Source	SS	DF	MS	F
Between Ss	40.373	263.000	0.000	0.000
A	3.938	3.000	1.313	9.368**
Subjs. w. grps.	36.435	260.000	0.140	0.000
Within Ss	5.819	528.000	0.000	0.000
B	1.848	2.000	0.924	121.770**
AB	0.024	6.000	0.004	0.522
Bx Subj. w. grps.	3.947	520.000	0.008	0.000

Table 49

Summary of Analysis of Variance for Quartiles of Fifth Amthauer Subtest (Factor A) by Scoring Methods (Factor B) Based on Loyola Problem 42.

Source	SS	DF	MS	F
Between Ss	26.623	263.000	0.000	0.000
A	1.068	3.000	0.356	3.620*
Subjs. w. grps.	25.555	260.000	0.098	0.000
Within Ss	10.736	528.000	0.000	0.000
B	7.161	2.000	3.581	525.479**
AB	0.032	6.000	0.005	0.778
Bx Subj. w. grps.	3.543	520.000	0.007	0.000

Table 50

Summary of Analysis of Variance for Quartiles of Fifth Amthauer Subtest (Factor A) by Scoring Methods (Factor B) Based on Loyola Problem 35A.

Source	SS	DF	MS	F
Between Ss	63.806	263.000	0.000	0.000
A	9.727	3.000	3.242	15.589**
Subjs. w. grps.	54.078	260.000	0.208	0.000
Within Ss	5.804	528.000	0.000	0.000
B	1.886	2.000	0.943	126.171**
AB	0.030	6.000	0.005	0.677
Bx Subj. w. grps.	3.887	520.000	0.007	0.000

Appendix III

Table 51

Summary of Analysis of Variance for Quartiles of Fifth Amthauer Subtest (Factor A) by Scoring Methods (Factor B) Based on Loyola Problem 35B.

Source	SS	DF	MS	F
Between Ss	57.656	263.000	0.000	0.000
A	2.963	3.000	0.988	4.696**
Subjs. w. grps.	54.692	260.000	0.210	0.000
Within Ss	3.062	528.000	0.000	0.000
B	0.202	2.000	0.101	18.816**
AB	0.073	6.000	0.012	2.259*
Bx Subj. w. grps.	2.787	520.000	0.005	0.000

Table 52

Summary of Analysis of Variance for Quartiles of Fifth Amthauer Subtest (Factor A) by Scoring Methods (Factor B) Based on Loyola Problem 35D.

Source	SS	DF	MS	F
Between Ss	56.335	263.000	0.000	0.000
A	3.519	3.000	0.173	5.774**
Subjs. w. grps.	52.817	260.000	0.203	0.000
Within Ss	3.599	528.000	0.000	0.000
B	0.335	2.000	0.168	27.074**
AB	0.046	6.000	0.008	1.249
Bx Subj. w. grps.	3.217	520.000	0.006	0.000

Table 53

Summary of Analysis of Variance for Quartiles of Sixth Amthauer Subtest (Factor A) by Scoring Methods (Factor B) Based on Loyola Problem 31A.

Source	SS	DF	MS	F
Between Ss	52.827	263.000	0.000	0.000
A	9.387	3.000	3.129	18.728**
Subjs. w. grps.	43.440	260.000	0.167	0.000
Within Ss	5.367	528.000	0.000	0.000
B	2.030	2.000	1.015	161.301**
AB	0.064	6.000	0.011	1.702
Bx Subj. w. grps.	3.272	520.000	0.006	0.000

Table 54

Summary of Analysis of Variance for Quartiles of Sixth Amthauer Subtest (Factor A) by Scoring Methods (Factor B) Based on Loyola Problem 31B.

Source	SS	DF	MS	F
Between Ss	40.525	263.000	0.000	0.000
A	3.012	3.000	1.004	6.958**
Subjs. w. grps.	37.513	260.000	0.144	0.000
Within Ss	5.388	528.000	0.000	0.000
B	2.327	2.000	1.163	198.227**
AB	0.010	6.000	0.002	0.282
Bx Subj. w. grps.	3.052	520.000	0.006	0.000

Table 55

Summary of Analysis of Variance for Quartiles of Sixth Amthauer Subtest (Factor A) by Scoring Methods (Factor B) Based on Loyola Problem 31D.

Source	SS	DF	MS	F
Between Ss	40.373	263.000	0.000	0.000
A	4.740	3.000	0.580	11.527**
Subjs. w. grps.	35.634	260.000	0.137	0.000
Within Ss	5.819	528.000	0.000	0.000
B	1.848	2.000	0.924	122.130**
AB	0.035	6.000	0.006	0.780
Bx Subj. w. grps.	3.935	520.000	0.008	0.000

Table 56

Summary of Analysis of Variance for Quartiles of Sixth Amthauer Subtest (Factor A) by Scoring Methods (Factor B) Based on Loyola Problem 42.

Source	SS	DF	MS	F
Between Ss	26.623	263.000	0.000	0.000
A	1.639	3.000	0.546	5.685**
Subjs. w. grps.	24.984	260.000	0.096	0.000
Within Ss	10.736	528.000	0.000	0.000
B	7.161	2.000	3.581	527.369**
AB	0.044	6.000	0.007	1.092
Bx Subj. w. grps.	3.530	520.000	0.007	0.000

Table 57

Summary of Analysis of Variance for Quartiles of Sixth Amthauer Subtest (Factor A) by Scoring Methods (Factor B) Based on Loyola Problem 35A.

Source	SS	DF	MS	F
Between Ss	63.806	263.000	0.000	0.000
A	9.067	3.000	3.022	14.356**
Subjs. w. grps.	54.738	260.000	0.211	0.000
Within Ss	5.804	528.000	0.000	0.000
B	1.886	2.000	0.943	125.655**
AB	0.014	6.000	0.002	0.320
Bx Subj. w. grps.	3.903	520.000	0.008	0.000

Table 58

Summary of Analysis of Variance for Quartiles of Sixth Amthauer Subtest (Factor A) by Scoring Methods (Factor B) Based on Loyola Problem 35B.

Source	SS	DF	MS	F
Between Ss	57.656	263.000	0.000	0.000
A	3.244	3.000	1.081	5.167**
Subjs. w. grps.	54.412	260.000	0.209	0.000
Within Ss	3.062	528.000	0.000	0.000
B	0.202	2.000	0.101	18.463**
AB	0.019	6.000	0.003	0.593
Bx Subj. w. grps.	2.841	520.000	0.005	0.000

Table 59

Summary of Analysis of Variance for Quartiles of Sixth Amthauer Subtest (Factor A) by Scoring Methods (Factor B) Based on Loyola Problem 35D.

Source	SS	DF	MS	F
Between Ss	56.335	263.000	0.000	0.000
A	3.672	3.000	1.224	6.043**
Subjs. w. grps.	52.663	260.000	0.203	0.000
Within Ss	3.599	528.000	0.000	0.000
B	0.335	2.000	0.168	27.654**
AB	0.114	6.000	0.019	3.131**
Bx Subj. w. grps.	3.150	520.000	0.006	0.000

Table 60

Summary of Analysis of Variance for Quartiles of Seventh Amthauer Subtest (Factor A) by Scoring Methods (Factor B) Based on Loyola Problem 31A.

Source	SS	DF	MS	F
Between Ss	52.827	263.000	0.000	0.000
A	4.780	3.000	1.593	8.623**
Subjs. w. grps.	48.046	260.000	0.185	0.000
Within Ss	5.367	528.000	0.000	0.000
B	2.030	2.000	1.015	160.592**
AB	0.050	6.000	0.008	1.312
Bx Subj. w. grps.	3.287	520.000	0.006	0.000

Table 61

Summary of Analysis of Variance for Quartiles of Seventh Amthauer Subtest (Factor A) by Scoring Methods (Factor B) Based on Loyola Problem 31B.

Source	SS	DF	MS	F
Between Ss	40.525	263.000	0.000	0.000
A	1.126	3.000	0.375	2.476
Subjs. w. grps.	39.400	260.000	0.152	0.000
Within Ss	5.388	528.000	0.000	0.000
B	2.327	2.000	1.163	198.699**
AB	0.017	6.000	0.003	0.488
Bx Subj. w. grps.	3.045	520.000	0.006	0.000

Table 62

Summary of Analysis of Variance for Quartiles of Seventh Amthauer Subtest (Factor A) by Scoring Methods (Factor B) Based on Loyola Problem 31D.

Source	SS	DF	MS	F
Between Ss	40.373	263.000	0.000	0.000
A	0.797	3.000	0.266	1.745
Subjs. w. grps.	39.577	260.000	0.152	0.000
Within Ss	5.819	528.000	0.000	0.000
B	1.848	2.000	0.924	122.669**
AB	0.053	6.000	0.009	1.165
Bx Subj. w. grps.	3.918	520.000	0.008	0.000

Table 63

Summary of Analysis of Variance for Quartiles of Seventh Amthauer Subtest (Factor A) by Scoring Methods (Factor B) Based on Loyola Problem 42.

Source	SS	DF	MS	F
Between Ss	26.623	263.000	0.000	0.000
A	0.281	3.000	0.094	0.925
Subjs. w. grps.	26.341	260.000	0.101	0.000
Within Ss	10.736	528.000	0.000	0.000
B	7.161	2.000	3.581	522.339**
AB	0.010	6.000	0.002	0.255
Bx Subj. w. grps.	3.564	520.000	0.007	0.000

Table 64

Summary of Analysis of Variance for Quartiles of Seventh Amthauer Subtest (Factor A) by Scoring Methods (Factor B) Based on Loyola Problem 35A.

Source	SS	DF	MS	F
Between Ss	63.806	263.000	0.000	0.000
A	4.995	3.000	0.665	7.361**
Subjs. w. grps.	58.810	260.000	0.226	0.000
Within Ss	5.804	528.000	0.000	0.000
B	1.886	2.000	0.943	126.567**
AB	0.042	6.000	0.007	0.950
Bx Subj. w. grps.	3.875	520.000	0.007	0.000

Table 65

Summary of Analysis of Variance for Quartiles of Seventh Amthauer Subtest (Factor A) by Scoring Methods (Factor B) Based on Loyola Problem 35B.

Source	SS	DF	MS	F
Between Ss	57.656	263.000	0.000	0.000
A	3.157	3.000	1.052	5.020**
Subjs. w. grps.	54.499	260.000	0.210	0.000
Within Ss	3.062	528.000	0.000	0.000
B	0.202	2.000	0.101	18.818**
AB	0.073	6.000	0.012	2.270*
Bx Subj. w. grps.	2.787	520.000	0.005	0.000

Table 66

Summary of Analysis of Variance for Quartiles of Seventh Amthauer Subtest (Factor A) by Scoring Methods (Factor B) Based on Loyola Problem 35D.

Source	SS	DF	MS	F
Between Ss	56.335	263.000	0.000	0.000
A	3.498	3.000	1.166	5.738**
Subjs. w. grps.	52.837	260.000	0.203	0.000
Within Ss	3.599	528.000	0.000	0.000
B	0.335	2.000	0.168	26.998**
AB	0.037	6.000	0.006	1.002
Bx Subj. w. grps.	3.226	520.000	0.006	0.000

Table 67

Summary of Analysis of Variance for Quartiles of Eighth Amthauer Subtest (Factor A) by Scoring Methods (Factor B) Based on Loyola Problem 31A.

Source	SS	DF	MS	F
Between Ss	52.827	263.000	0.000	0.000
A	3.348	3.000	1.116	5.865
Subjs. w. grps.	49.479	260.000	0.190	0.000
Within Ss	5.367	528.000	0.000	0.000
B	2.030	2.000	1.015	161.224**
AB	0.063	6.000	0.010	1.657
Bx Subj. w. grps.	3.274	520.000	0.006	0.000

Table 68

Summary of Analysis of Variance for Quartiles of Eighth Amthauer Subtest (Factor A) by Scoring Methods (Factor B) Based on Loyola Problem 31B.

Source	SS	DF	MS	F
Between Ss	40.525	263.000	0.000	0.000
A	2.176	3.000	0.725	4.917**
Subjs. w. grps.	38.349	260.000	0.147	0.000
Within Ss	5.388	528.000	0.000	0.000
B	2.327	2.000	0.163	198.423**
AB	0.013	6.000	0.002	0.368
Bx Subj. w. grps.	3.049	520.000	0.006	0.000

Table 69

Summary of Analysis of Variance for Quartiles of Eighth Amthauer Subtest (Factor A) by Scoring Methods (Factor B) Based on Loyola Problem 31D.

Source	SS	DF	MS	F
Between Ss	40.373	263.000	0.000	0.000
A	0.952	3.000	0.317	2.094
Subjs. w. grps.	39.421	260.000	0.152	0.000
Within Ss	5.819	528.000	0.000	0.000
B	1.848	2.000	0.924	124.613**
AB	0.114	6.000	0.019	2.556*
Bx Subj. w. grps.	3.857	520.000	0.007	0.000

Table 70

Summary of Analysis of Variance for Quartiles of Eighth Amthauer Subtest (Factor A) by Scoring Methods (Factor B) Based on Loyola Problem 42.

Source	SS	DF	MS	F
Between Ss	26.623	263.000	0.000	0.000
A	0.118	3.000	0.039	0.386
Subjs. w. grps.	26.505	260.000	0.102	0.000
Within Ss	10.736	528.000	0.000	0.000
B	7.161	2.000	3.581	523.627**
AB	0.019	6.000	0.003	0.469
Bx Subj. w. grps.	3.556	520.000	0.007	0.000

Table 71

Summary of Analysis of Variance for Quartiles of Eighth Amthauer Subtest (Factor A) by Scoring Methods (Factor B) Based on Loyola Problem 35A.

Source	SS	DF	MS	F
Between Ss	63.806	263.000	0.000	0.000
A	3.057	3.000	1.019	4.361**
Subjs. w. grps.	60.749	260.000	0.234	0.000
Within Ss	5.804	528.000	0.000	0.000
B	1.886	2.000	0.943	126.126**
AB	0.029	6.000	0.005	0.645
Bx Subj. w. grps.	3.889	520.000	0-007	0.000

Table 72

Summary of Analysis of Variance for Quartiles of Eighth Amthauer Subtest (Factor A) by Scoring Methods (Factor B) Based on Loyola Problem 35B.

Source	SS	DF	MS	F
Between Ss	57.656	263.000	0.000	0.000
A	2.714	3.000	0.905	4.282**
Subjs. w. grps.	54.941	260.000	0.211	0.000
Within Ss	3.062	528.000	0.000	0.000
B	0.202	2.000	0.101	19.044**
AB	0.106	6.000	0.018	3.341**
Bx Subj. w. grps.	2.754	520.000	0.005	0.000

Table 73

Summary of Analysis of Variance for Quartiles of Eighth Amthauer Subtest (Factor A) by Scoring Methods (Factor B) Based on Loyola Problem 35D.

Source	SS	DF	MS	F
Between Ss	56.335	263.000	0.000	0.000
A	2.574	3.000	0.858	4.149**
Subjs. w. grps.	53.762	260.000	0.207	0.000
Within Ss	3.599	528.000	0.000	0.000
B	0.335	2.000	0.168	26.944**
AB	0.031	6.000	0.005	0.826
Bx Subj. w. grps.	3.233	520.000	0.006	0.000

Table 74

Summary of Analysis of Variance for Quartiles of Ninth Amthauer Subtest (Factor A) by Scoring Methods (Factor B) Based on Loyola Problem 31A.

Source	SS	DF	MS	F
Between Ss	52.827	263.000	0.000	0.000
A	4.617	3.000	1.539	8.301**
Subjs. w. grps.	48.209	260.000	0.185	0.000
Within Ss	5.367	528.000	0.000	0.000
B	2.030	2.000	1.015	167.115**
AB	0.178	6.000	0.030	4.885**
Bx Subj. w. grps.	3.159	520.000	0.006	0.000

Table 75

Summary of Analysis of Variance for Quartiles of Ninth Amthauer Subtest (Factor A) by Scoring Methods (Factor B) Based on Loyola Problem 31B.

Source	SS	DF	MS	F
Between Ss	40.525	263.000	0.000	0.000
A	2.001	3.000	0.667	4.501**
Subjs. w. grps.	38.524	260.000	0.148	0.000
Within Ss	5.388	528.000	0.000	0.000
B	2.327	2.000	1.163	198.270**
AB	0.011	6.000	0.002	0.301
Bx Subj. w. grps.	3.051	520.000	0.006	0.000

Table 76

Summary of Analysis of Variance for Quartiles of Ninth Amthauer Subtest (Factor A) by Scoring Methods (Factor B) Based on Loyola Problem 31D.

Source	SS	DF	MS	F
Between Ss	40.373	263.000	0.000	0.000
A	2.042	3.000	0.681	4.617**
Subjs. w. grps.	38.331	260.000	0.147	0.000
Within Ss	5.819	528.000	0.000	0.000
B	1.848	2.000	0.924	122.771**
AB	0.056	6.000	0.009	1.238
Bx Subj. w. grps.	3.914	520.000	0.008	0.000

Table 77

Summary of Analysis of Variance for Quartiles of Ninth Amthauer Subtest (Factor A) by Scoring Methods (Factor B) Based on Loyola Problem 42.

Source	SS	DF	MS	F
Between Ss	26.623	263.000	0.000	0.000
A	0.357	3.000	0.119	1.178
Subjs. w. grps.	26.266	260.000	0.101	0.000
Within Ss	10.736	528.000	0.000	0.000
B	7.161	2.000	3.581	526.111**
AB	0.036	6.000	0.006	0.882
Bx Subj. w. grps.	3.539	520.000	0.007	0.000

Table 78

Summary of Analysis of Variance for Quartiles of Ninth Amthauer Subtest (Factor A) by Scoring Methods (Factor B) Based on Loyola Problem 35A.

Source	SS	DF	MS	F
Between Ss	63.806	263.000	0.000	0.000
A	6.740	3.000	2.247	10.236**
Subjs. w. grps.	57.065	260.000	0.219	0.000
Within Ss	5.804	528.000	0.000	0.000
B	1.886	2.000	0.943	126.169**
AB	0.030	6.000	0.005	0.676
Bx Subj. w. grps.	3.887	520.000	0.007	0.000

Table 79

Summary of Analysis of Variance for Quartiles of Ninth Amthauer Subtest (Factor A) by Scoring Methods (Factor B) Based on Loyola Problem 35B.

Source	SS	DF	MS	F
Between Ss	57.656	263.000	0.000	0.000
A	2.056	3.000	0.685	3.205*
Subjs. w. grps.	55.599	260.000	0.214	0.000
Within Ss	3.062	528.000	0.000	0.000
B	0.202	2.000	0.101	18.738**
AB	0.061	6.000	0.010	1.890
Bx Subj. w. grps.	2.799	520.000	0.005	0.000

Table 80

Summary of Analysis of Variance for Quartiles of Ninth Amthauer Subtest (Factor A) by Scoring Methods (Factor B) Based on Loyola Problem 35D.

Source	SS	DF	MS	F
Between Ss	56.335	263.000	0.000	0.000
A	1.522	3.000	0.507	2.406
Subjs. w. grps.	54.813	260.000	0.211	0.000
Within Ss	3.599	528.000	0.000	0.000
B	0.335	2.000	0.168	26.781**
AB	0.011	6.000	0.002	0.297
Bx Subj. w. grps.	3.252	520.000	0.006	0.000

Table 81

Summary of Analysis of Variance for Levels of Academic Achievement (Factor A) by Scoring Methods (Factor B) Based on Loyola Problem 31A.

Source	SS	DF	MS	F
Between Ss	48.321	239.000	0.000	0.000
A	6.516	2.000	3.258	18.471**
Subjs. w. grps.	41.805	237.000	0.176	0.000
Within Ss	4.955	480.000	0.000	0.000
B	1.834	2.000	0.917	141.095**
AB	0.040	4.000	0.010	1.636
Bx Subj. w. grps.	3.081	474.000	0.006	0.000

Table 82

Summary of Analysis of Variance for Levels of Academic Achievement (Factor A) by Scoring Methods (Factor B) Based on Loyola Problem 31B.

Source	SS	DF	MS	F
Between Ss	36.453	239.000	0.000	0.000
A	5.863	2.000	2.932	22.714**
Subjs. w. grps.	30.590	237.000	0.129	0.000
Within Ss	5.178	480.000	0.000	0.000
B	2.237	2.000	1.119	180.805**
AB	0.009	4.000	0.002	0.330
Bx Subj. w. grps.	2.933	474.000	0.006	0.000

Table 83

Summary of Analysis of Variance for Levels of Academic Achievement (Factor A) by Scoring Methods (Factor B) Based on Loyola Problem 31D.

Source	SS	DF	MS	F
Between Ss	35.646	239.000	0.000	0.000
A	5.615	2.000	2.807	22.155**
Subjs. w. grps.	30.031	237.000	0.127	0.000
Within Ss	5.103	480.000	0.000	0.000
B	1.588	2.000	0.794	107.805**
AB	0.024	4.000	0.006	0.836
Bx Subj. w. grps.	3.491	474.000	0.007	0.000

Appendix III

Table 84

Summary of Analysis of Variance for Levels of Academic Achievement (Factor A) by Scoring Methods (Factor B) Based on Loyola Problem 42.

Source	SS	DF	MS	F
Between Ss	24.569	239.000	0.000	0.000
A	1.677	2.000	0.839	8.683**
Subjs. w. grps.	22.891	237.000	0.097	0.000
Within Ss	9.604	480.000	0.000	0.000
B	6.387	2.000	3.194	471.186**
AB	0.004	4.000	0.001	0.196
Bx Subj. w. grps.	3.213	474.000	0.007	0.000

Table 85

Summary of Analysis of Variance for Levels of Academic Achievement (Factor A) by Scoring Methods (Factor B) Based on Loyola Problem 35A.

Source	SS	DF	MS	F
Between Ss	55.978	239.000	0.000	0.000
A	9.942	2.000	4.971	25.590**
Subjs. w. grps.	46.037	237.000	0.194	0.000
Within Ss	5.416	480.000	0.000	0.000
B	1.773	2.000	0.886	115.405**
AB	0.003	4.000	0.001	0.126
Bx Subj. w. grps.	3.640	474.000	0.008	0.000

Table 86

Summary of Analysis of Variance for Levels of Academic Achievement (Factor A) by Scoring Methods (Factor B) Based on Loyola Problem 35B.

Source	SS	DF	MS	F
Between Ss	52.241	239.000	0.000	0.000
A	4.824	2.000	2.412	12.055**
Subjs. w. grps.	47.417	237.000	0.200	0.000
Within Ss	2.974	480.000	0.000	0.000
B	0.173	2.000	0.087	14.835**
AB	0.033	4.000	0.008	1.343
Bx Subj. w. grps.	2.768	474.000	0.006	0.000

Table 87

Summary of Analysis of Variance for Levels of Academic Achievement (Factor A) by Scoring Methods (Factor B) Based on Loyola Problem 35D.

Source	SS	DF	MS	F
Between Ss	52.864	239.000	0.000	0.000
A	5.151	2.000	2.575	12.793**
Subjs. w. grps.	47.713	237.000	0.201	0.000
Within Ss	3.333	480.000	0.000	0.000
B	0.341	2.000	0.171	27.044**
AB	0.001	4.000	0.000	0.017
Bx Subj. w. grps.	2.991	474.000	0.006	0.000

Table 88

Summary of Analysis of Variance for Levels of Academic Achievement Based on First Amthauer Subtest

Source	SS	DF	MS	F
Treat.	366.525	2.000	183.263	31.133**
Error	1395.075	237.000	5.886	
Total	1761.600	239.000		

Table 89

Summary of Analysis of Variance for Levels of Academic Achievement Based on Second Amthauer Subtest

Source	SS	DF	MS	F
Treat.	702.434	2.000	351.217	54.577**
Error	1525.150	237.000	6.435	
Total	2227.584	239.000		

Table 90

Summary of Analysis of Variance for Levels of Academic Achievement Based on Third Amthauer Subtest

Source	SS	DF	MS	F
Treat.	1241.734	2.000	620.867	72.700**
Error	2024.000	237.000	8.540	
Total	3265.734	239.000		

Table 91

Summary of Analysis of Variance for Levels of Academic Achievement Based on Fourth Amthauer Subtest

Source	SS	DF	MS	F
Treat.	1967.108	2.000	983.554	75.863**
Error	3072.688	237.000	12.965	
Total	5039.796	239.000		

Table 92

Summary of Analysis of Variance for Levels of Academic Achievement Based on Fifth Amthauer Subtest

Source	SS	DF	MS	F
Treat.	1103.175	2.000	551.588	65.472**
Error	1996.675	237.000	8.425	
Total	3099.850	239.000		

Table 93

Summary of Analysis of Variance for Levels of Academic Achievement Based on Sixth Amthauer Subtest

Source	SS	DF	MS	F
Treat.	736.225	2.000	368.113	20.490**
Error	4257.738	237.000	17.965	
Total	4993.963	239.000		

Table 94

Summary of Analysis of Variance for Levels of Academic Achievement Based on Seventh Amthauer Subtest

Source	SS	DF	MS	F
Treat.	237.359	2.000	118.680	10.752**
Error	2615.975	237.000	11.038	
Total	2853.334	239.000		

Table 95

Summary of Analysis of Variance for Levels of Academic Achievement Based on Eighth Amthauer Subtest

Source	SS	DF	MS	F
Treat.	18.959	2.000	9.480	0.984
Error	2283.775	237.000	9.636	
Total	2302.734	239.000		

Table 96

Summary of Analysis of Variance for Levels of Academic Achievement Based on Ninth Amthauer Subtest

Source	SS	DF	MS	F
Treat.	589.259	2.000	294.630	22.727**
Error	3072.475	237.000	12.964	
Total	3661.734	239.000		

Table 97

Summary of Analysis of Variance for Piaget Stages
of Combination Experiment (Factor A)
by Levels of Instrinsic Difficulty (Factor B)
by Levels of Extrinsic Difficulty (Factor C)

Source	SS	DF	MS	F
Between Ss	34.47	184.000	0.00	0.00
A	2.92	2.00	1.46	8.43**
Ss w. grps.	31.55	182.00	0.17	0.00
Within Ss	79.51	925.00	0.09	0.00
B	0.20	1.00	0.20	3.79
AB	0.05	2.00	0.03	0.49
Bx Ss w. grps.	9.64	182.00	0.05	0.00
C	12.79	2.00	6.39	91.78**
AC	0.73	4.00	0.18	2.61*
Cx Ss w. grps.	25.36	364.00	0.07	0.00
BC	0.59	2.00	0.30	3.63*
ABC	0.45	4.00	0.11	1.37
BCx Ss w. grps.	29.71	364.00	0.08	0.00

Table 98

Summary of Analysis of Variance for Piaget Stages
of Probability Experiment (Factor A)
by Levels of Instrinsic Difficulty (Factor B)
by Levels of Extrinsic Difficulty (Factor C)

Source	SS	DF	MS	F
Between Ss	34.47	184.00	0.00	0.00
A	0.07	2.00	0.04	0.19
Ss w. grps.	34.40	182.00	0.19	0.00
Within Ss	79.49	925.00	0.09	0.00
B	0.20	1.00	0.20	3.84
AB	0.17	2.00	0.08	1.58
Bx Ss w. grps.	9.52	182.00	0.05	0.00
C	12.79	2.00	6.39	90.50**
AC	0.37	4.00	0.09	1.30
Cx Ss w. grps.	25.72	364.00	0.07	0.00
BC	0.59	2.00	0.30	3.58*
ABC	0.05	4.00	0.01	0.16
BCx Ss w. grps.	30.08	364.00	0.08	0.00

Appendix III

Table 99

Summary of Analysis of Variance for Piaget Stages of Balance Experiment (Factor A) by Levels of Instrinsic Difficulty (Factor B) by Levels of Extrinsic Difficulty (Factor C)

Source	SS	DF	MS	F
Between Ss	34.47	184.00	0.00	0.00
A	1.71	2.00	0.86	4.76**
Ss w. grps.	32.76	182.00	0.18	0.00
Within Ss	79.54	925.00	0.09	0.00
B	0.20	1.00	0.20	3.77
AB	0.00	2.00	0.00	0.01
Bx Ss w. grps.	9.69	182.00	0.05	0.00
C	12.79	2.00	6.39	90.11**
AC	0.26	4.00	0.06	0.90
Cx Ss w. grps.	25.83	364.00	0.07	0.00
BC	0.59	2.00	0.30	3.59*
ABC	0.12	4.00	0.03	0.36
BCx Ss w. grps.	30.06	364.00	0.08	0.00

Table 100

Summary of Analysis of Variance for Piaget
Stages of Combinations Experiment Based on Loyola Problem 42.

Source	SS	DF	MS	F
Treat.	0.04	2	0.02	0.41
Error	9.01	182	0.05	
Total	9.05	184		

Table 101

Summary of Analysis of Variance for Piaget
Stages of Probability Experiment Based on Loyola Problem 42.

Source	SS	DF	MS	F
Treat.	0.04	2	0.02	0.41
Error	9.01	182	0.05	
Total	9.05	184		

Table 102

Summary of Analysis of Variance for Piaget
Stages of Balance Experiment Based on Loyola Problem 42.

Source	SS	DF	MS	F
Treat.	0.00	2	0.00	0.01
Error	9.05	182	0.05	
Total	9.05	184		

Appendix III

Table 103

Summary of Analysis of Variance for Piaget Stages of Combinations Experiment Based on First Amthauer Subtest

Source	SS	DF	MS	F
Treat.	19.72	2	9.86	1.28
Error	1401.72	182	7.70	
Total	1421.44	184		

Table 104

Summary of Analysis of Variance for Piaget Stages of Probability Experiment Based on First Amthauer Subtest

Source	SS	DF	MS	F
Treat.	79.93	2	39.97	5.42**
Error	1341.51	182	7.37	
Total	1421.44	184		

Table 105

Summary of Analysis of Variance for Piaget Stages of Balance Experiment Based on First Amthauer Subtest

Source	SS	DF	MS	F
Treat.	73.58	2	36.79	4.97**
Error	1347.86	182	7.41	
Total	1421.44	184		

Table 106

Summary of Analysis of Variance for Piaget Stages of Combinations Experiment Based on Second Amthauer Subtest

Source	SS	DF	MS	F
Treat.	55.72	2	27.86	3.50*
Error	1448.49	182	7.96	
Total	1504.22	184		

Table 107

Summary of Analysis of Variance for Piaget Stages of Probability Experiment Based on Second Amthauer Subtest

Source	SS	DF	MS	F
Treat.	114.98	2	57.49	7.53**
Error	1389.24	182	7.63	
Total	1504.22	184		

Table 108

Summary of Analysis of Variance for Piaget Stages of Balance Experiment Based on Second Amthauer Subtest

Source	SS	DF	MS	F
Treat.	40.73	2	20.37	2.53
Error	1463.48	182	8.04	
Total	1504.22	184		

Table 109

Summary of Analysis of Variance for Piaget Stages of Combinations Experiment Based on Third Amthauer Subtest

Source	SS	DF	MS	F
Treat.	219.82	2	109.91	9.07**
Error	2206.43	182	12.12	
Total	2426.25	184		

Table 110

Summary of Analysis of Variance for Piaget Stages of Probability Experiment Based on Third Amthauer Subtest

Source	SS	DF	MS	F
Treat.	185.56	2	92.78	7.54**
Error	2240.69	182	12.31	
Total	2426.25	184		

Table 111

Summary of Analysis of Variance for Piaget Stages of Balance Experiment Based on Third Amthauer Subtest

Source	SS	DF	MS	F
Treat.	91.84	2	45.92	3.58**
Error	2334.41	182	12.83	
Total	2426.25	184		

Table 112

Summary of Analysis of Variance for Piaget Stages of Combinations Experiment Based on Fourth Amthauer Subtest

Source	SS	DF	MS	F
Treat.	228.23	2	114.12	5.72**
Error	3631.98	182	19.96	
Total	3860.22	184		

Table 113

Summary of Analysis of Variance for Piaget Stages of Probability Experiment Based on Fourth Amthauer Subtest

Source	SS	DF	MS	F
Treat.	278.67	2	139.34	7.08**
Error	3581.55	182	19.68	
Total	3860.22	184		

Table 114

Summary of Analysis of Variance for Piaget Stages of Balance Experiment Based on Fourth Amthauer Subtest

Source	SS	DF	MS	
Treat.	83.98	2	41.99	2.02
Error	3776.24	182	20.75	
Total	3860.22	184		

Table 115

Summary of Analysis of Variance for Piaget
Stages of Combinations Experiment Based on Fifth Amthauer Subtest

Source	SS	DF	MS	F
Treat.	312.01	2	156.00	13.56**
Error	2093.43	182	11.50	
Total	2405.44	184		

Table 116

Summary of Analysis of Variance for Piaget
Stages of Probability Experiment Based on Fifth Amthauer Subtest

Source	SS	DF	MS	F
Treat.	171.48	2	85.74	6.99**
Error	2233.96	182	12.27	
Total	2405.44	184		

Table 117

Summary of Analysis of Variance for Piaget
Stages of Balance Experiment Based on Fifth Amthauer Subtest

Source	SS	DF	MS	F
Treat.	200.64	2	100.32	8.28**
Error	2204.80	182	12.11	
Total	2405.44	184		

Table 118

Summary of Analysis of Variance for Piaget Stages of Combinations Experiment Based on Sixth Amthauer Subtest

Source	SS	DF	MS	F
Treat.	276.83	2	138.41	7.41**
Error	3399.15	182	18.68	
Total	3675.98	184		

Table 119

Summary of Analysis of Variance for Piaget Stages of Probability Experiment Based on Sixth Amthauer Subtest

Source	SS	DF	MS	F
Treat.	44.01	2	22.00	1.10**
Error	3631.97	182	19.96	
Total	3675.98	184		

Table 120

Summary of Analysis of Variance for Piaget Stages of Balance Experiment Based on Sixth Amthauer Subtest

Source	SS	DF	MS	F
Treat.	186.71	2	93.35	4.87**
Error	3489.27	182	19.17	
Total	3675.98	184		

Table 121

Summary of Analysis of Variance for Piaget
Stages of Combinations Experiment Based on Seventh Amthauer Subtest

Source	SS	DF	MS	F
Treat.	151.01	2	75.51	6.76**
Error	2033.34	182	11.17	
Total	2184.35	184		

Table 122

Summary of Analysis of Variance for Piaget
Stages of Probability Experiment Based on Seventh Amthauer Subtest

Source	SS	DF	MS	F
Treat.	8.33	2	4.17	0.35
Error	2176.02	182	11.96	
Total	2184.35	184		

Table 123

Summary of Analysis of Variance for Piaget
Stages of Balance Experiment Based on Seventh Amthauer Subtest

Source	SS	DF	MS	F
Treat.	16.01	2	8.01	0.67
Error	2168.33	182	11.91	
Total	2184.35	184		

Table 124

Summary of Analysis of Variance for Piaget Stages of Combinations Experiment Based on Eighth Amthauer Subtest

Source	SS	DF	MS	F
Treat.	12.93	2	6.47	0.63
Error	1882.83	182	10.35	
Total	1895.76	184		

Table 125

Summary of Analysis of Variance for Piaget Stages of Probability Experiment Based on Eighth Amthauer Subtest

Source	SS	DF	MS	F
Treat.	4.34	2	2.17	0.21
Error	1891.43	182	10.39	
Total	1895.76	184		

Table 126

Summary of Analysis of Variance for Piaget Stages of Balance Experiment Based on Eighth Amthauer Subtest

Source	SS	DF	MS	F
Treat.	67.20	2	33.60	3.34*
Error	1828.56	182	10.05	
Total	1895.76	184		

Appendix III

Table 127

Summary of Analysis of Variance for Piaget Stages of Combinations Experiment Based on Ninth Amthauer Subtest

Source	SS	DF	MS	F
Treat.	29.91	2	14.96	0.96
Error	2825.53	182	15.52	
Total	2855.44	184		

Table 128

Summary of Analysis of Variance for Piaget Stages of Probability Experiment Based on Ninth Amthauer Subtest

Source	SS	DF	MS	F
Treat.	6.17	2	3.08	0.20
Error	2849.27	182	15.66	
Total	2855.44	184		

Table 129

Summary of Analysis of Variance for Piaget Stages of Balance Experiment Based on Ninth Amthauer Subtest

Source	SS	DF	MS	F
Treat.	41.72	2	20.86	1.35
Error	2813.72	182	15.46	
Total	2855.44	184		

Appendix III

Table 130

Intercorrelations of Amthauer Subtests and Loyola Problems
Based on Entire Sample, N=264*

	SE	WA	AN	GE	RA	ZR	FA	WÜ	ME	31A	31B	31D	42	35A	35B	35D
SE		50	48	47	39	42	26	16	30	36	27	18	16	26	11	21
WA			57	53	39	30	28	18	30	26	.26	23	19	30	17	15
AN				58	51	45	35	16	36	41	32	29	26	30	17	22
GE					53	35	28	02	33	37	20	27	16	25	18	16
RA						60	34	12	31	36	18	27	09	35	19	25
ZR							38	20	28	43	23	31	19	34	22	30
FA								37	16	24	12	13	08	21	20	25
WÜ									20	19	08	03	02	12	09	21
ME										28	14	16	08	25	12	15
31A											31	22	28	40	29	25
31B												11	23	27	19	14
31D													15	21	25	32
42														22	15	11
35A															27	16
35B																39

* Decimal points omitted.

Table 131

Unrotated Principal Axes Factor Solution for
Combined Loyola and Amthauer Batteries, N=264

	1	2	3	4	5	6	7	8
SE	.097	-.060	.037	-.029	.128	.625	.057	.031
WA	.004	.150	.257	.008	-.070	.639	-.090	.002
AN	-.083	-.103	.067	-.185	.005	.738	.008	-.025
GE	.042	.120	.119	.121	-.122	.669	.008	-.049
RA	-.057	.038	-.195	.013	.157	.689	-.030	.143
ZR	.000	-.048	-.298	.022	-.144	.679	-.040	.129
FA	.023	.151	.031	.021	.042	.475	.117	.347
WÜ	-.002	-.171	.051	.052	.030	.280	-.080	.420
ME	-.039	.067	-.012	.029	.018	.458	.063	.085
31A	.068	.164	-.160	-.042	.005	.600	-.110	-.154
31B	-.149	.019	-.047	.100	.002	.399	.025	-.248
31D	.008	.003	.133	.059	.108	.410	.001	-.131
42	.047	-.021	-.038	.050	.054	.307	.034	-.323
35A	.046	-.079	-.176	-.044	.087	.509	.076	-.176
35B	.001	-.090	.188	-.015	.103	.374	.044	-.165
35D	-.017	.056	.216	-.044	-.156	.409	.047	.048
Eigen Values	.055	-.157	.376	-.076	-.142	4.59	-.062	.612

Appendix III

Table 131 (Continued)

Unrotated Principal Axes Factor Solution for
Combined Loyola and Amthauer Batteries, N=264

	9	10	11	12	13	14	15	16
SE	-.070	-.013	.215	-.002	.090	-.131	-.221	.000
WA	.005	-.149	.011	-.019	.115	.070	-.301	.005
AN	-.084	.042	-.110	.010	.028	-.006	-.224	-.026
GE	.036	.138	-.023	.014	-.171	.007	-.324	.003
RA	.035	-.006	.023	-.009	-.291	.093	-.079	.110
ZR	-.132	-.059	.022	-.029	-.146	-.076	.127	-.083
FA	-.112	.036	-.057	.007	.085	.161	.140	-.057
WÜ	.022	-.017	-.054	.015	.317	-.036	.212	.042
ME	.307	.030	-.076	-.028	.067	-.189	-.088	.033
31A	.042	.130	-.009	.030	.129	-.038	.145	.005
31B	-.072	.013	.127	.018	.250	-.004	.042	-.013
31D	-.032	-.120	-.104	.047	-.263	-.123	.173	-.042
42	-.164	.004	-.176	-.042	.173	-.031	.068	.067
35A	.188	-.132	.002	.022	.110	.140	.128	.030
35B	.099	.043	.065	-.036	-.064	.135	.424	-.072
35D	-.038	.034	.066	-.003	-.127	-.106	.429	.100
Eigen Values	.221	.101	.138	-.010	.480	.172	.826	-.048